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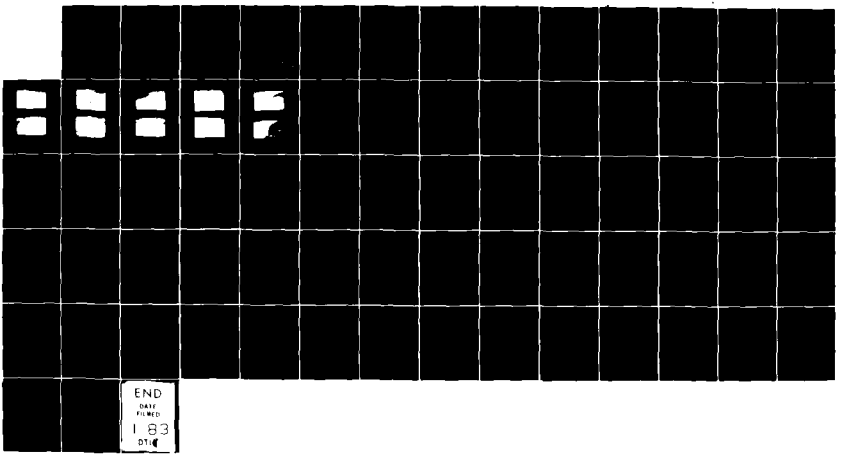

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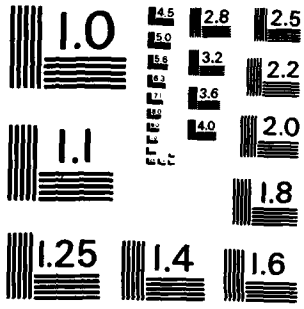

QUANTIFYING MINOR SEDIMENT SOURCES BANK EROSION AND FLOOD PLAIN SCOUR, GREAT III

A REPORT SUBMITTED TO

U.S. Army Corps of Engineers
St. Louis District

PREPARED BY

The Institute of River Studies
University of Missouri-Rolla
Rolla, Missouri 65401

August 1982

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Bank erosion and/or fill and flood plain scour and fill as sources of sediment yield were quantified. The method used to quantify bank erosion and/or fill was to map the high bank along the GREAT III reach. The results obtained from this method indicate that only small changes in the bankline location over the 22 years studied have occurred. Sensitivity analyses were included to show what effect the error incurred in the methodology used may have on the results.

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QUANTIFYING MINOR SEDIMENT SOURCES

BANK EROSION AND FLOOD PLAIN SCOUR, GREAT III

A Report Submitted to

The Department of the Army

St. Louis District, Corps of Engineers

by

Institute of River Studies

University of Missouri-Rolla

Rolla, Missouri

Dr. Charles D. Morris, Project Director

Contract No. DACW43-81-C-0071

August 1982

ABSTRACT

This study attempts to quantify bank erosion and/or fill and flood plain scour and fill as sources of sediment yield within the GREAT III study area. Mapping of the high bank along the entire stretch of the Mississippi under study was the method used to quantify bank erosion and/or fill.

Various methods are available for delineation and mapping of the high bank. The method chosen included a method of resection using a zoom stereoscope. A more exact method of delineation and mapping of the bank was prohibited due to costs, availability of equipment, a difference of scale between maps and photos, and the accuracy of existing sediment records.

The results obtained from the method used indicates that there have been only small changes in the bankline location over the 22 years studied. Sensitivity analyses are included in order to show what effect the error incurred in the methodology used may have on results.

ACKNOWLEDGEMENTS

The authors wish to acknowledge all individuals whose support contributed to the completion of this study. A special thanks to members of the Great River Environmental Action Team who funded this study. Mr. Vernon Finney, Chairman, GREAT III Erosion and Sediment Work Group, and Messrs. Claude Strauser, Wayne Berkus, Tim Lazaro, Keith Donnelson, Joe Marshall, Robert Piest and Dr. Allen Hjelmfelt.

Mr. James T. Lovelace, Chief of the Hydrologic and Hydraulics Branch, St. Louis District Corps of Engineers, for his assistance throughout the study. A special thanks to the following St. Louis Corps personnel: Mr. Paul Olson and Mr. Claude Strauser who provided technical assistance in the retrieval and collection of data.

A special thanks to the following personnel of the Soil Conservation Service: Les Volmert, Charles Eddy, Daniel Switzner and Charles Wright for their assistance in supplying aerial photographs needed for completion of the study.

Dr. Paul Munger, Director of the Institute of River Studies, who provided administrative assistance in the completion of the study. Drs. Glendon T. Stevens, Jr. and Roger Smith, fellow members of the Institute of River Studies, who provided editorial assistance in writing the final report.

A very special thanks to Mrs. Donna Sell, Mrs. Jean Kramme and Mrs. Kayla Brockman, secretaries of the Institute of River Studies, who typed the rough draft and final study report. Without their efforts, this study could not have been completed.

Student help was vital to the completion of this project. In addition, graduate student Mark Jourdan performed a variety of analyses and helped supervise the students in the development of the maps used in the study.

To recognize by name everyone who assisted in the completion of this study would be difficult, if not impossible, but to each of those not mentioned, we say thanks for your valuable contributions.

This study was administered through the St. Louis District of the U.S. Army Corps of Engineers under Contract Number DACW43-81-C-0071.

TABLE OF CONTENTS

I. INTRODUCTION

The primary objectives of this study were to quantify bank erosion and flood plain scour and/or fill within the GREAT III study area. Thus, a primary objective of this study was to determine and quantify the transportation of the river erosion and deposition. Since the river is a dynamic system and is continually changing, causing the channel to scour or undercut banks at one point and deposit sediment at another, a reference to quantify net bank erosion and/or fill was needed for this study. The reference selected was the high bank since its change in location is indicative of net deposition and/or scour within a given reach of the river. The high banks were continuously defined from aerial photographs of the river and flood plain. These photographs were from three different time periods, 1975-1976, 1967-1968 and 1953-1956. The mapping covers the entire 303 miles of river over approximately a 20-year time period. This investigation addressed concerns about bank erosion and/or fill between Saverton, Missouri and Cairo, Illinois on the Mississippi River. Also, as part of this study, an attempt was made to quantify flood plain scour and/or deposition by the collection and investigation of potential sources of information. These sources were Corps of Engineers records of materials removed, of scour holes filled and aerial photographs. After careful examination of these records it was determined that little or no quantitative information could be gained from these sources. Throughout this study every reasonable effort was expended within the scope of the project to quantiatively determine the bank and flood plain scour and/or fill within the GREAT III study area.

II. ANALYSIS OF RIVER HIGH BANKS

A. Collection of Data

One of the major efforts required in the undertaking of the project was the determination and collection of the available data. Aerial photographs are the only source of data which would provide information needed for this study. An aerial photograph directory from the St. Louis Corps of Engineers was obtained. From this directory, aerial photographs were selected, having at least a 60% overlap, for viewing stereoscopically. After examination of the directory, three different periods of photographs were available for study--The Corps of Engineers, St. Louis District, had to send to the National Archives for the selected photographs.

B. Development of Overlays

After the photographs were obtained and the high bank was selected as a reference for net deposition and/or scour, it was necessary to decide on the method of delineation of the high bank. The photographs were taken to the United States Geological Survey (USGS) to get a cost estimate for delineating the high bankline. It was agreed, after a number of discussions with the USGS, that the procedure to be used involved making glass positives and then using their control and contouring techniques to make continuous designation of the high bankline. A cost estimate was received for this procedure that greatly exceeded available funds.

Another method, currently in use in work of this nature, entails use of a zoom transfer scope. One of the problems associated with this procedure

is that individual photos are required. Since most of the photos obtained for this study were on continuous rolls, this would have entailed having a duplicate strip printed and separating into individual photographs. Once again, the cost associated with this method was prohibitive, considering the increase in accuracy obtained.

The procedure developed for use included the Bausch and Lomb, Zoom 95 Stereoscope. The purpose of the stereoscope is to create a spatial, three-dimensional model from the data included in the two photographs of a stereopair. The photographic images which make up a stereopair must be properly oriented with each other and with the stereoscope to achieve optimum results.

The left and right banklines were delineated on the aerial photographs with the use of a stereoscope and are identified on 7½ minute USGS topographic maps (1:24,000 scale) as a series of triangles, circles, and squares, for each time period as illustrated in Figure 1. These points were transferred from the aerial photographs by means of resection from two known reference points. This is a method by which a high bank point on the photographs could be transferred to the map by knowing the distances from that point to at least two known control reference points. Control reference points, such as a house or an intersection of two highways, common to both the photographs and the map, and between 30° and 150° apart, were chosen to measure the distance to the bankline as illustrated by heavy dashed lines in Figure 1. Arcs were drawn using that distance as a radius, and the point of intersection of two arcs was the high bank. This procedure was followed for each of the three time periods, using different symbols for each period. This results in maps of the river

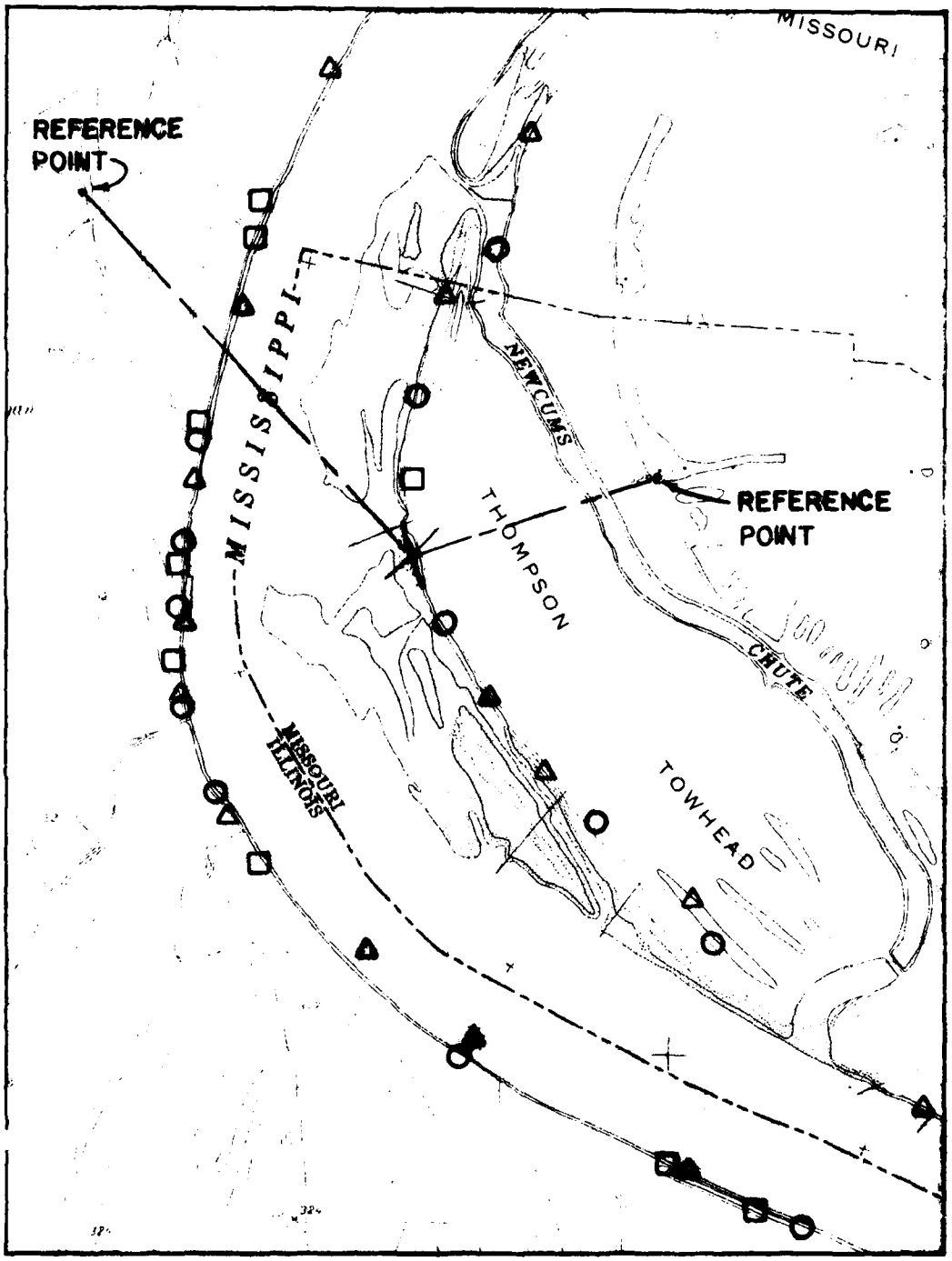


ILLUSTRATION OF RESECTION METHOD

Figure 1

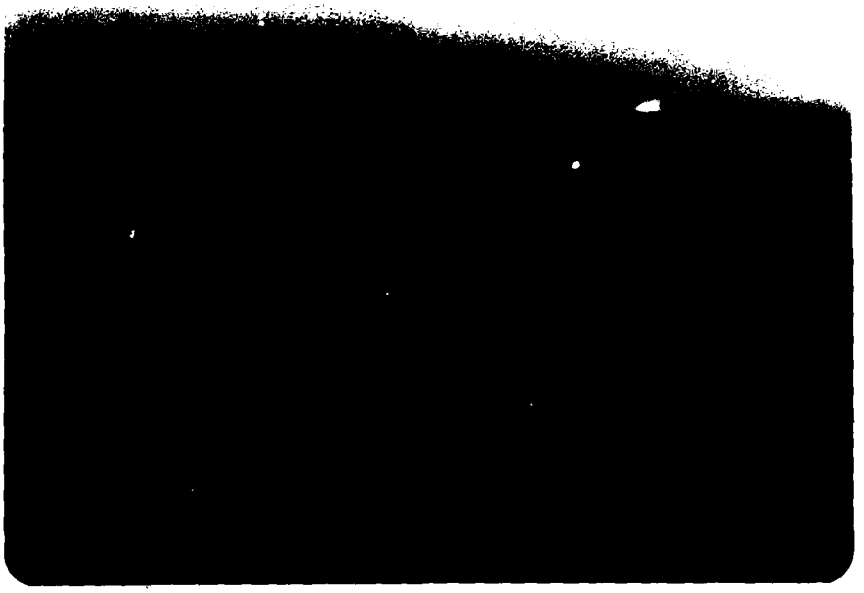
showing the left and right bankline and its change with time (1-45). This straight forward approach required compensation for the different scales encountered with the aerial photographs. Photo copies of these base maps are available from St. Louis District, Corps of Engineers.

The margin of error of this procedure was estimated to be approximately 200 feet. The problem in obtaining greater accuracy, either through the method used in this study, or other methods discussed, is the differing scales of the photos from period to period. The photographs used had scales of either 1:10,000, 1:20,000 or 1:24,000, with the base maps having a scale of 1:24,000. When using different scales, such as those encountered in this study, the level of accuracy becomes less dependent on the method used. Since the process used to transfer data from one scale to another becomes more important in determining the accuracy, the method used for delineation becomes less important.

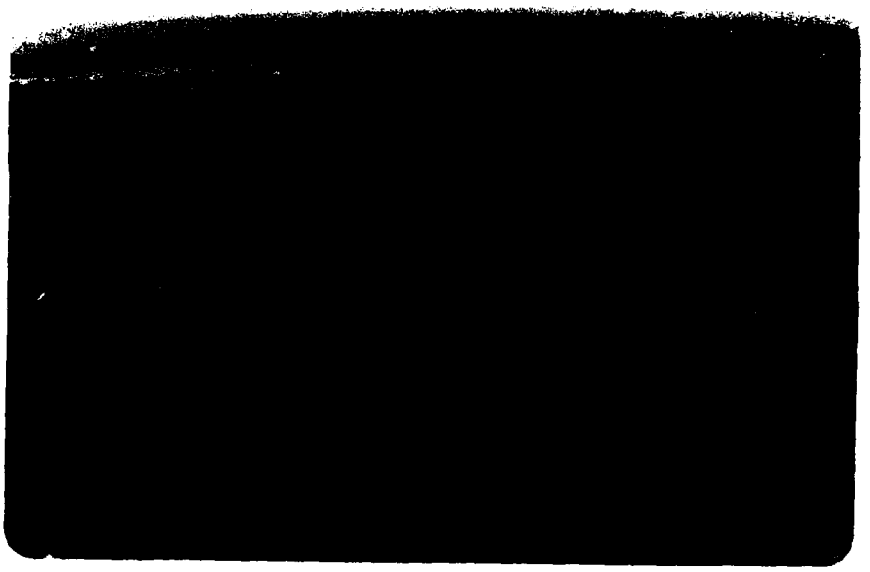
C. Site Observations

Site observations were performed and aerial photos were taken when the river was at high bank stage. A 35mm camera was used, with the photographs being taken from an airplane of each of the areas delineated from Maps 1-45 as erosion or deposition areas. The purpose of these observations was to document the existing conditions at these sites, and to aid in quantifying the amount of erosion or deposition. An attempt was made at surface observations and it was determined that an overall perspective could not be obtained due to the dense overgrowth of vegetation and trees.

Following are photographs obtained and discussion of existing conditions at each of the sites.

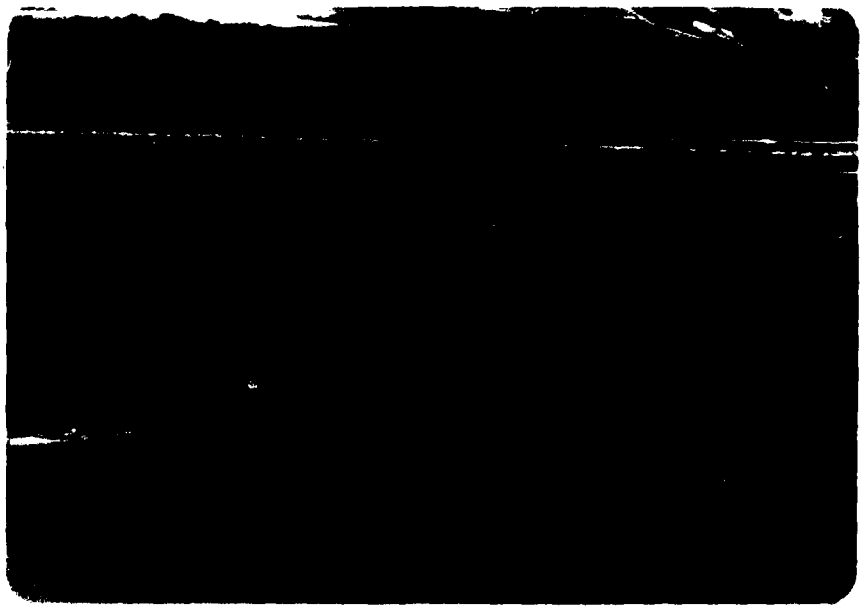


1.1. Site 1 looking southwest. Note the two dikes, one just below Brown's Bar and the other one upstream. Deposition is evident between the two dikes.



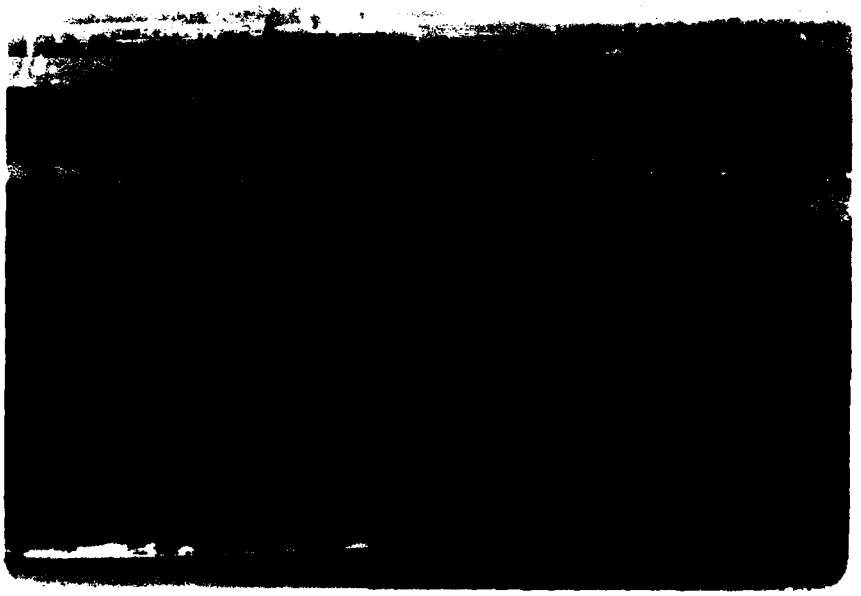
1.2. Site 1 looking west. Note the two dikes and the deposition in between.

2.1. Site 2 looking northeast. Note location of the two dikes, one on each side of the small island. Also note the different heights of trees, implying deposition and new growth.

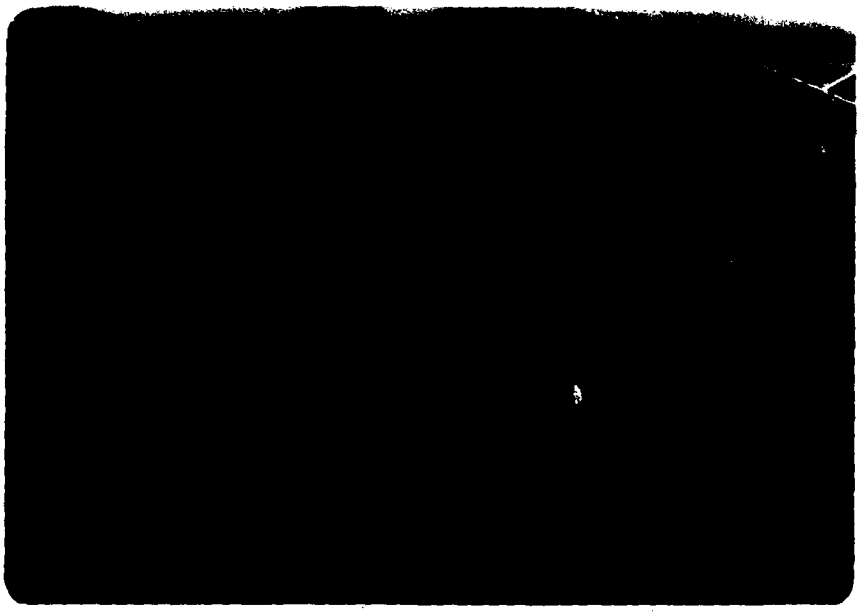


2.2. Site 2 looking east. Note the difference in the vegetation, the shorter trees being a result of recent deposition.

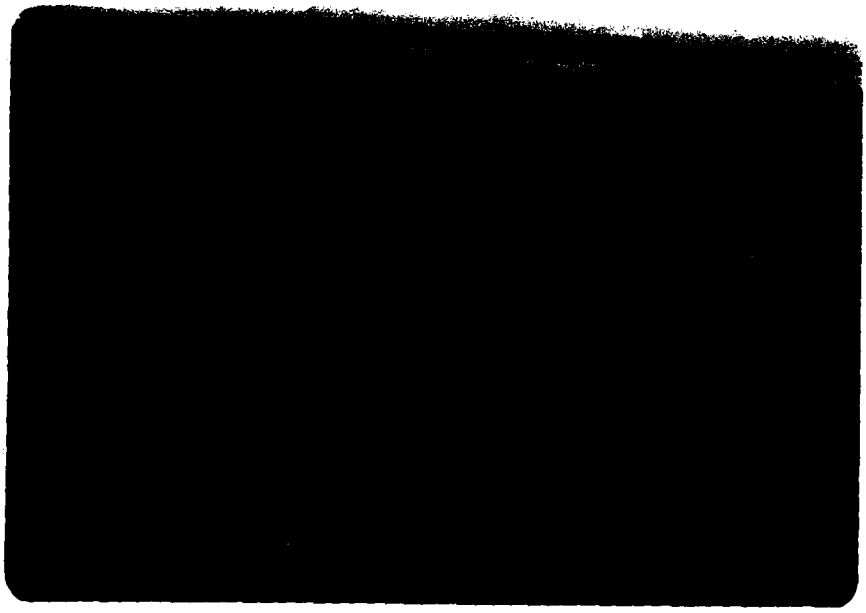
3.1. Site 3 looking north. Note the two dikes, one between Beagle Island and the mainland, and the other dike going out from Beagle Island.



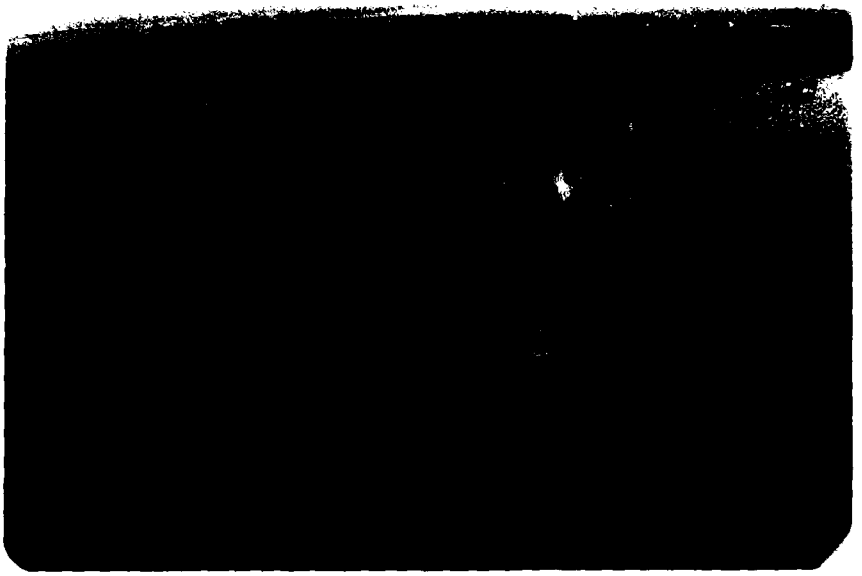
3.2. Site 3 looking northeast. Note the different levels of vegetation, indicating area of most recent deposition.



4.1. Site 4 looking northwest. Area of deposition is the triangular area in the center of the photo.



4.2. Site 4 looking west. Note different levels of tree height.



5.1. Site 5 looking NNW. Area of erosion is at and below the triangular area of growth.

5.2. Site 5 looking northwest. Another view of erosion area.

D. Computation

After the mapping was completed, the entire 303 miles of river from Saverton, Missouri to Cairo, Illinois, was evaluated to determine if there had been any significant change in the bankline during the 20-year period studied.

Five areas were found that had a significant change in the high bankline, with time. Four of the five areas were deposition areas. These four areas appear to have been formed by the placement of dikes, which accreted sediment. The other area was an erosion area. Detailed volumes for the five areas are presented below.

The length and width of deposition or erosion was determined from the results of the mapping. The depth of deposition or erosion was estimated with the aid of the hydrographic surveys taken along the Mississippi River over the years. With the use of cross sections taken near or at the five areas of concern, and knowing the extent of change laterally, the average depth of deposition or erosion was determined.

Deposition

Site 1: Map 4 Quad: Cache, Ill-Mo
Mile 21 Left Bank
Tip of Dogtooth Island
Estimated Volume of Change = 7000' x 600' x 40'
Minimum Volume = 6900' x 500' x 40'
Maximum Volume = 7100' x 700' x 40'

Site 2: Map 17 Quad: Kaskaskia, Ill-Mo
Mile 115 Left Bank
South of Fort Gage
Estimated Volume of Change = 8000' x 600' x 40'
Minimum Volume = 7900' x 500' x 40'
Maximum Volume = 8100' x 700' x 40'

Site 3: Map 20 Quad: Bloomsdale, Mo-Ill
Mile 138 Left Bank
Beagles Island
Estimated Volume of Change = 18000' x 2000' x 10'
Minimum Volume = 17900' x 1900' x 10'
Maximum Volume = 18100' x 2100' x 10'

Deposition
(continued)

Site 4: Map 21 Quad: Selman, Ill-Mo
Mile 144 Left Bank
Harlow Island
Estimated Volume of Change = 4000' x 600' x 20'
Minimum Volume = 3900' x 500' x 20'
Maximum Volume = 4100' x 700' x 20'

Erosion

Site 5: Map 4 Quad: Cache, Ill-Mo
Mile 18 Left Bank
Dogtooth Island
Estimated Volume of Change = 3000' x 200' x 40'
Minimum Volume = 2900' x 100' x 40'
Maximum Volume = 3100' x 300' x 40'

The margin of error was estimated to be 100 feet for the procedures used, and is well within the accuracy of the sediment records now available. As an example, suppose 100 feet of bankline, 30 feet high, and for one mile of river, has been eroded over a 20-year period. This is equivalent to 0.07% of the total sediment load being transported down the river at Hannibal, Missouri, which is within the accuracy of the available sediment records.

A detailed analysis using Hannibal, Missouri sediment data follows. Sediment data from Hannibal, Missouri was used because it was the only location where sediment data has been taken for the 20-year period studied. Since the Hannibal gage has less total sediment transport than the gages listed, this will lead to a worse case analysis.

The purpose of the sensitivity analysis is to indicate the total error possible for different margins of error. A matrix of length, width, and depth was evaluated for the analysis. The possible contribution to the sediment load was then calculated for each case, and the percentage of the total sediment load during the period studied is given.

SENSITIVITY ANALYSIS

Percentage of total sediment load at Hannibal, Missouri

½ MILE	Width (ft)	Depth (ft)	10	20	30	40	50
	50		.006	.012	.018	.023	.029
	100		.012	.023	.035	.048	.059
	200		.023	.047	.071	.095	.118
	2000		.237	.474	.711	.949	1.186

1 MILE	Width (ft)	Depth (ft)	10	20	30	40	50
	50		.012	.024	.036	.047	.029
	100		.024	.047	.071	.095	.119
	200		.047	.095	.142	.190	.237
	2000		.474	.949	1.423	1.898	2.372

5 MILES	Width (ft)	Depth (ft)	10	20	30	40	50
	50		.060	.120	.180	.235	.295
	100		.120	.235	.355	.475	.595
	200		.240	.470	.710	.950	1.190
	2000		2.370	4.745	7.115	9.490	11.860

10 MILES	Width (ft)	Depth (ft)	10	20	30	40	50
	50		.12	.24	.36	.47	.59
	100		.24	.47	.71	.95	1.19
	200		.47	.95	1.42	1.90	2.37
	2000		4.74	9.49	14.23	18.98	23.72

20 MILES	Width (ft)	Depth (ft)	10	20	30	40	50
	50		.24	.48	.72	.94	1.18
	100		.48	.94	1.42	1.90	2.38
	200		.94	1.90	2.84	3.80	4.74
	2000		9.48	18.98	28.46	37.96	47.44

50 MILES	Width (ft)	Depth (ft)	10	20	30	40	50
	50		.60	1.20	1.80	2.35	2.95
	100		1.20	2.35	3.55	4.75	5.95
	200		2.40	4.70	7.10	9.50	11.90
	2000		23.70	47.45	71.15	94.90	118.60

100 MILES	Width (ft)	Depth (ft)	10	20	30	40	50
	50		1.20	2.40	3.60	4.70	5.90
	100		2.40	4.7	7.1	9.5	11.9
	200		4.70	9.50	14.20	19.00	23.70
	2000		47.40	94.90	142.30	189.80	237.20

303 MILES	Width (ft)	Depth (ft)	10	20	30	40	50
(Total Reach of River Studies)	50		3.64	7.27	10.92	14.24	17.88
	100		7.27	14.24	21.51	28.79	36.06
	200		14.24	28.79	43.03	57.75	71.87
	2000		143.62	287.55	431.26	575.09	718.72

III. CONCLUSIONS

The results of the mapping of the high bankline indicate there have been only small changes over the 22 years studied. It must also be noted that the five areas of change all occurred below St. Louis. As expected, upstream from St. Louis, no changes in bankline location were found. This is probably due to the many man-made controls placed on that reach of the river. With the many locks and dams, most of the river is in slow moving pools where the high bankline has been stabilized.

The five areas of deposition or erosion that were found all underwent change during the first thirteen years studied, that is from 1953-1956 to 1967-1968. Three of these sites were above the Chester, Illinois gage and the other two were below the Thebes, Illinois gage. Below are listed the five sites and the amount of change per year, based on the previously discussed 13-year period, since all changes occurred during that time period. Along with the annual change is a comparison to the Hannibal, Missouri sediment gage. The Hannibal gage was used since it was the only gage found with complete data during the period.

Site 1: Amount of change = 969,000 $\pm$ 2,000 Tons/year (Deposition)
% of Total Sediment Load (at Hannibal) = .76 $\pm$ .002

Site 2: Amount of change = 1,110,000 $\pm$ 2,000 Tons/year (Deposition)
% of Total Sediment Load (at Hannibal) = .86 $\pm$ .002

Site 3: Amount of change = 2,077,000 $\pm$ 580 Tons/year (Deposition)
% of Total Sediment Load (at Hannibal) = 1.62 $\pm$ .0005

Site 4: Amount of change = 277,000 $\pm$ 1,150 Tons/year (Deposition)
% of Total Sediment Load (at Hannibal) = .22 $\pm$ .001

Site 5: Amount of change = 138,000 ± 2,000 Tons/year (Erosion)
% of Total Sediment Load (at Hannibal) = .11 ± .002

Net Deposition = 4,433,000 ± 5,730 Tons/year
% of Total Sediment Load (at Hannibal) = 3.45 ± .005

Net Erosion = 138,000 ± 2,000 Tons/year
% of Total Sediment Load (at Hannibal) = .11 ± .002

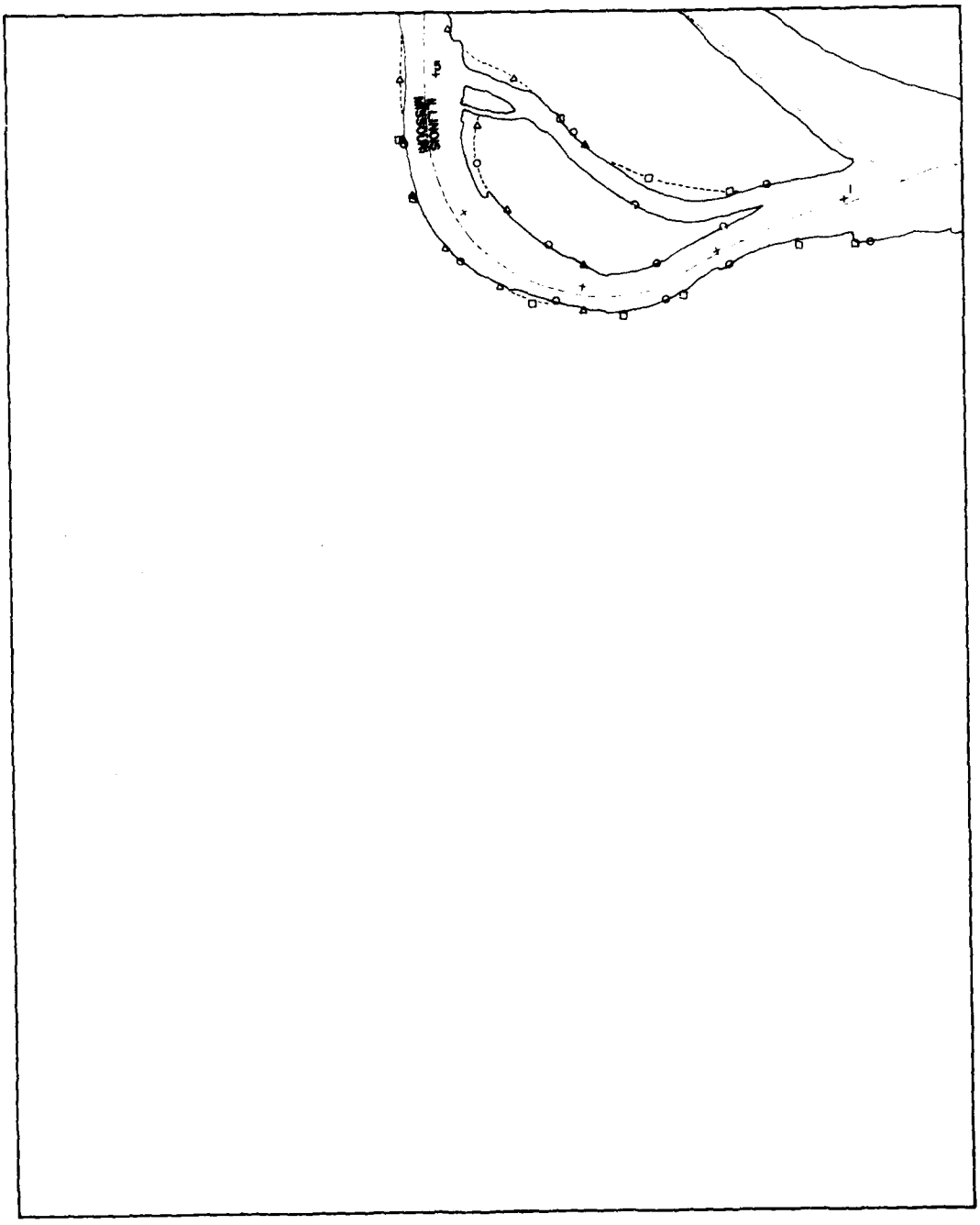
This is within the accuracy of sediment records and therefore this analysis indicates that bank erosion and deposition is not a significant factor in the total sediment budget of the river.

The results of this investigation are substantiated by the River Training and Revetment Works of the Corps of Engineers. Since the intent of the Corps' program during the period of study has been to stabilize bank caving and since the major part of the revetment program has been in place for a period of time, large scale erosion and deposition of the high bank is no longer a significant factor and the river's high bank is now in virtual equilibrium.

APPENDIX

(Maps 1-45)

Note: The high bankline that was delineated in this study is designated on the maps as a dashed line as shown on the legends of the accompanying maps. The solid line on the maps is the waterline at the time of the aerial flights and was delineated from the U.S.G.S. maps.

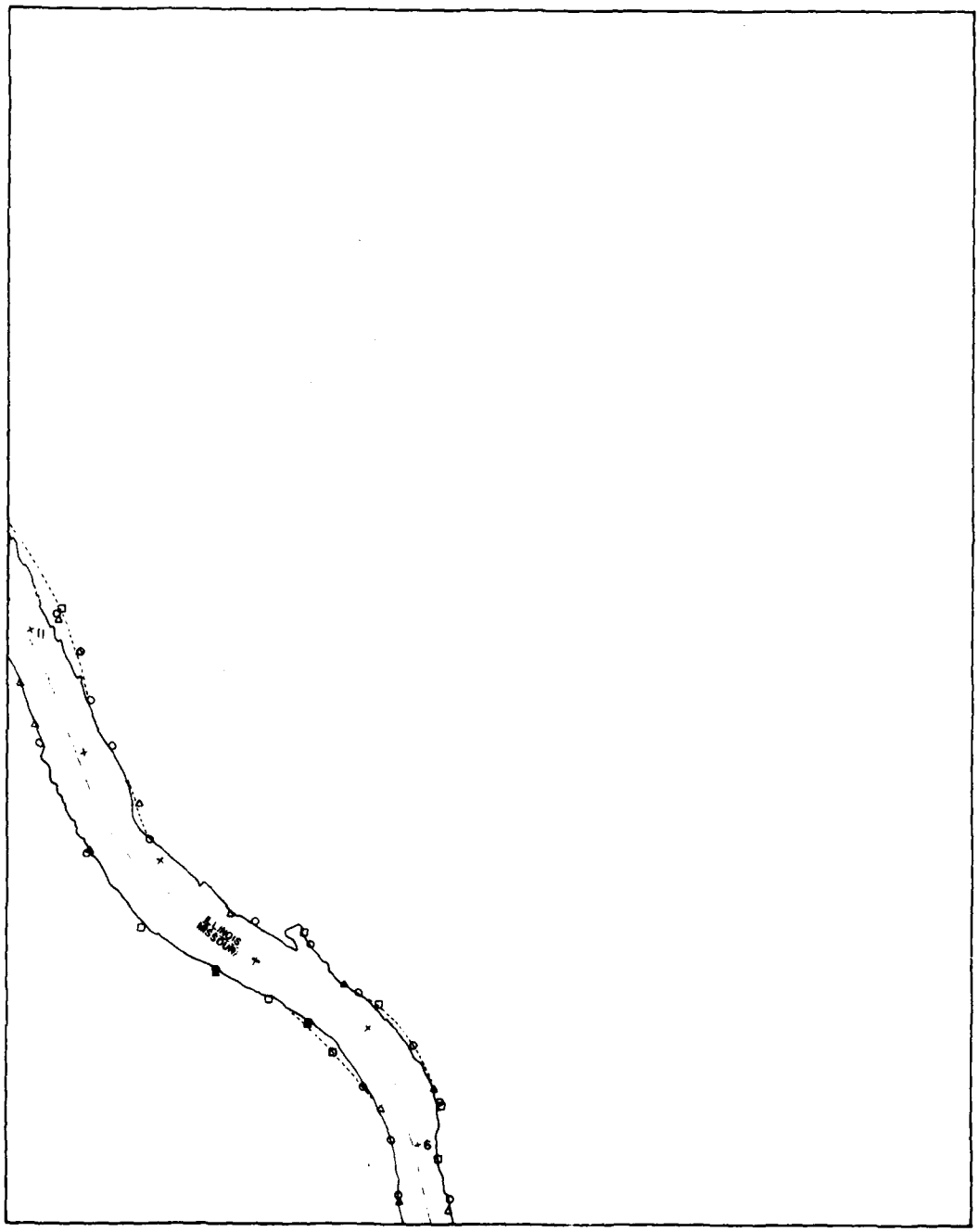


---- HIGH BAR LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

WYATT QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 1

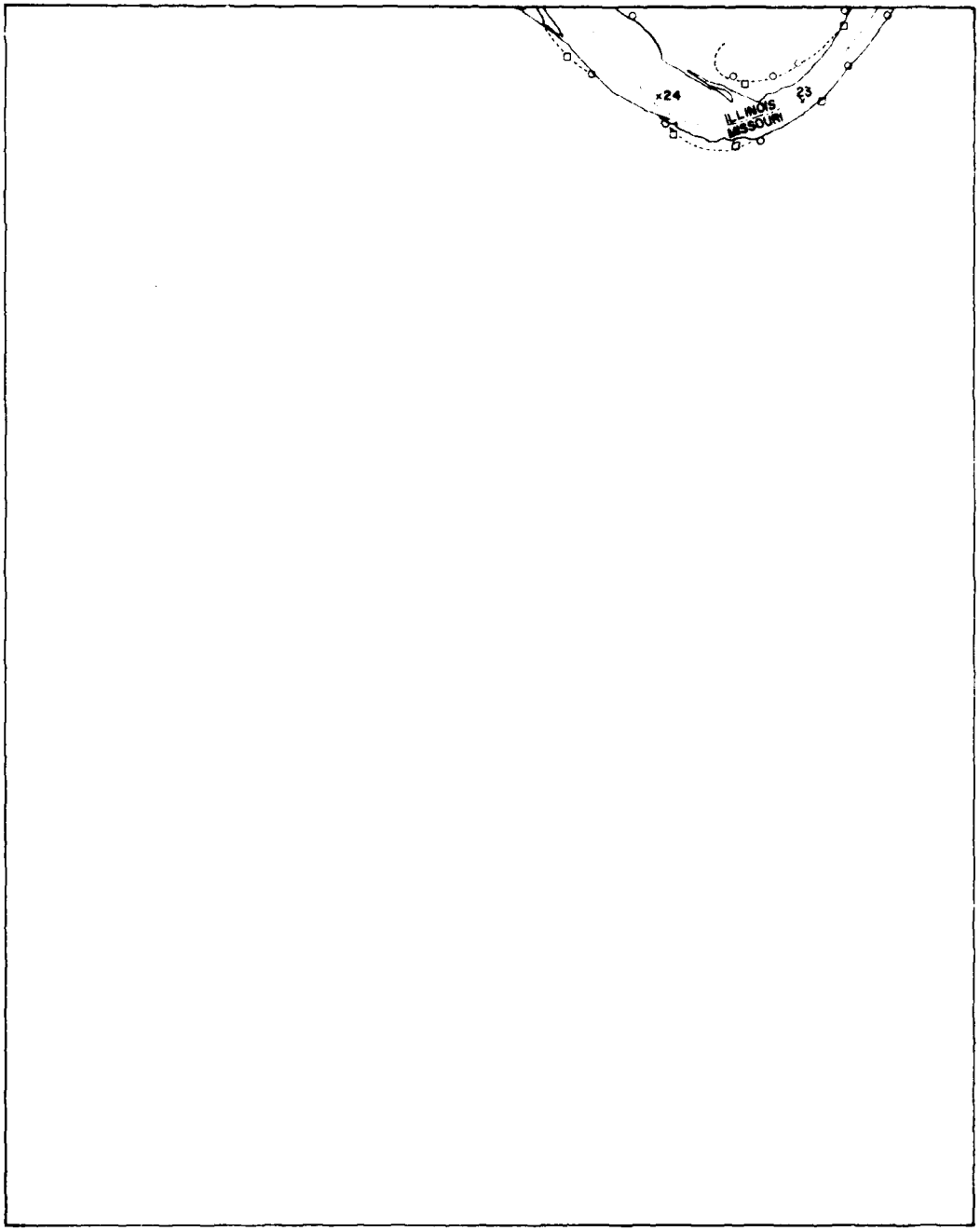


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1963-68
○ - 1967-68
□ - 1975-78

CAIRO QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 2

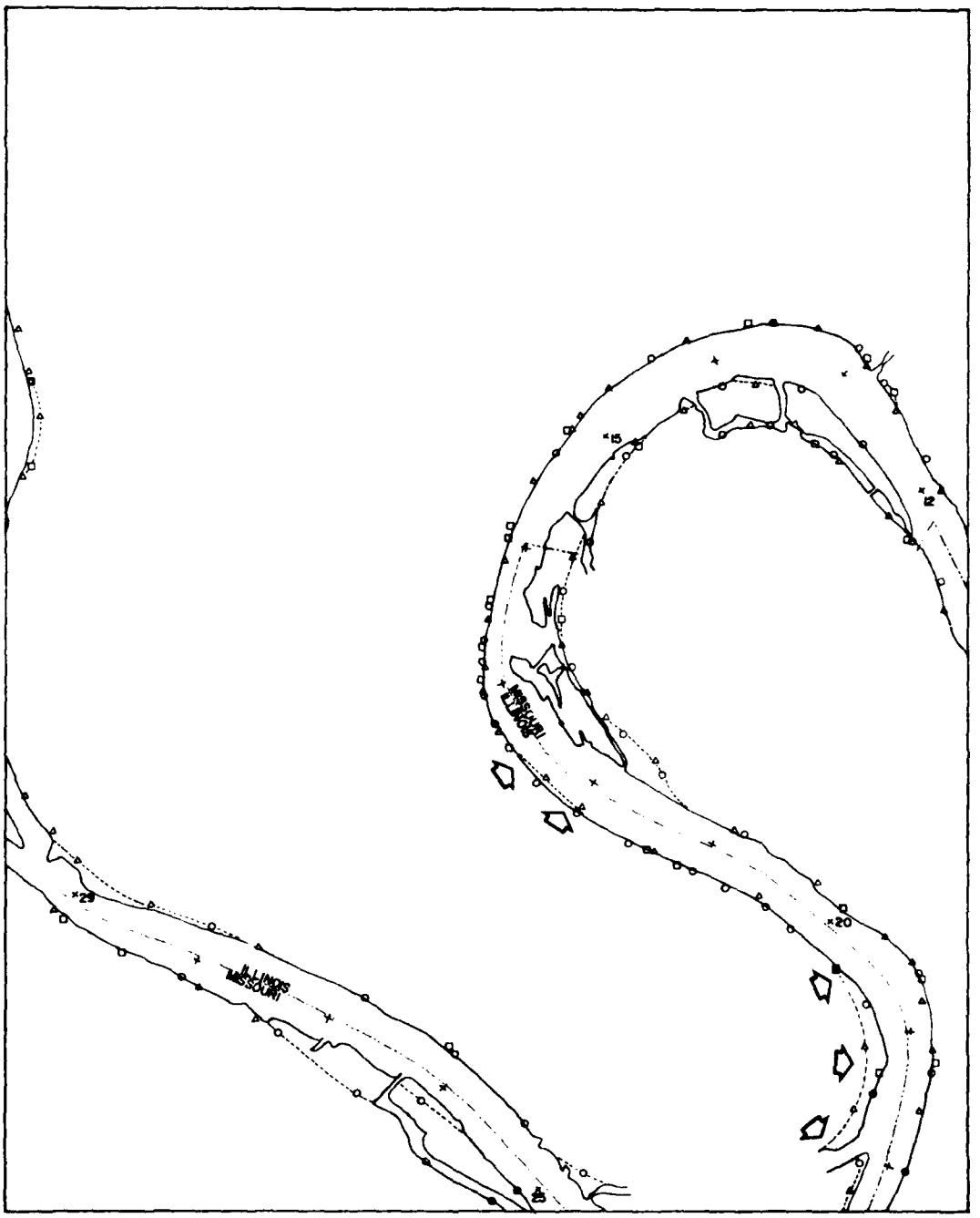


··· HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-56
○ - 1967-68
□ - 1975-76

CHARLESTON QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 3

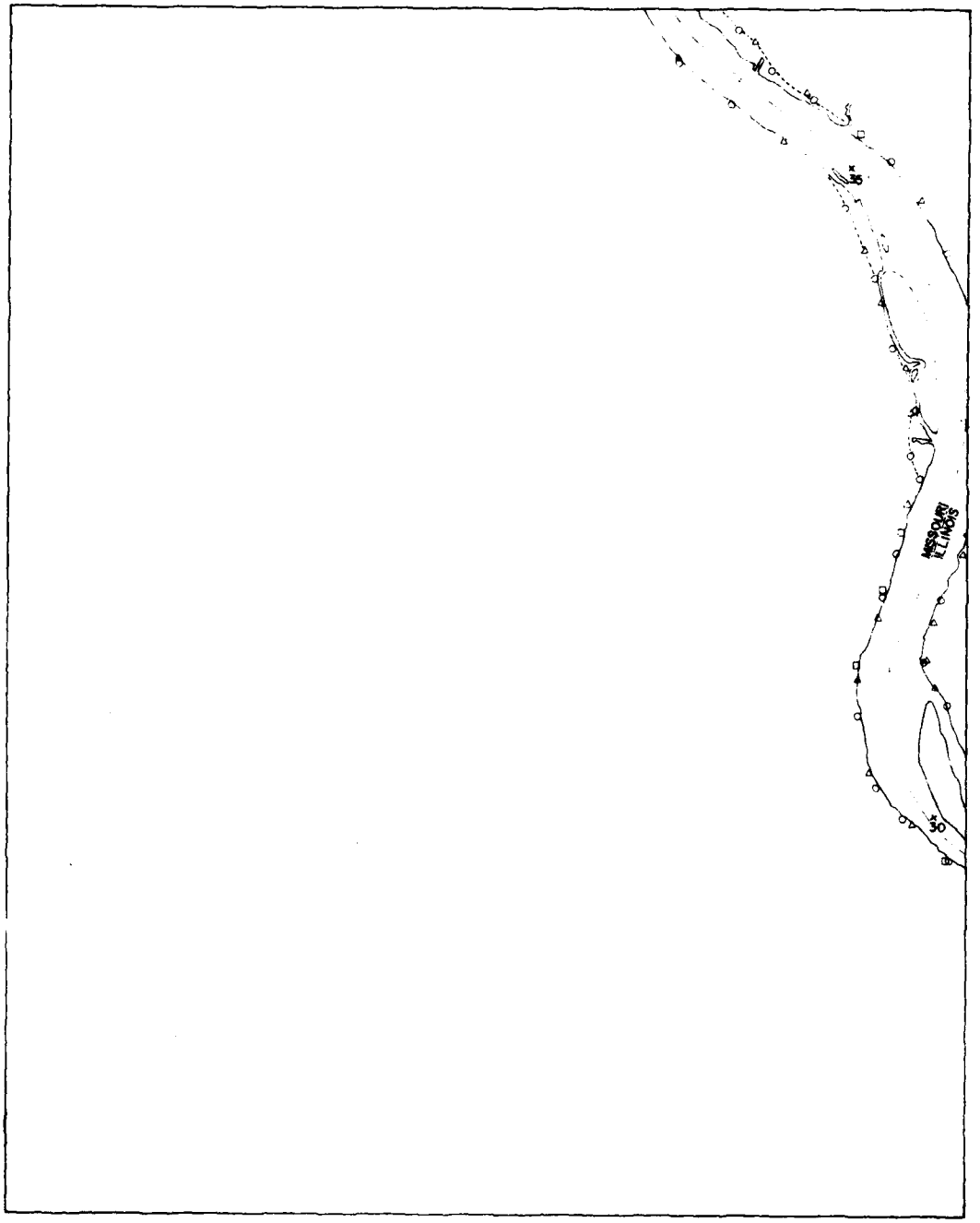


---- HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
▲ – 1953-58
○ – 1967 68
□ – 1975-78

CACHE QUADRANGLE
7.5 MINUTE SERIES
1967

1000' 0' 7000'

MAP 4

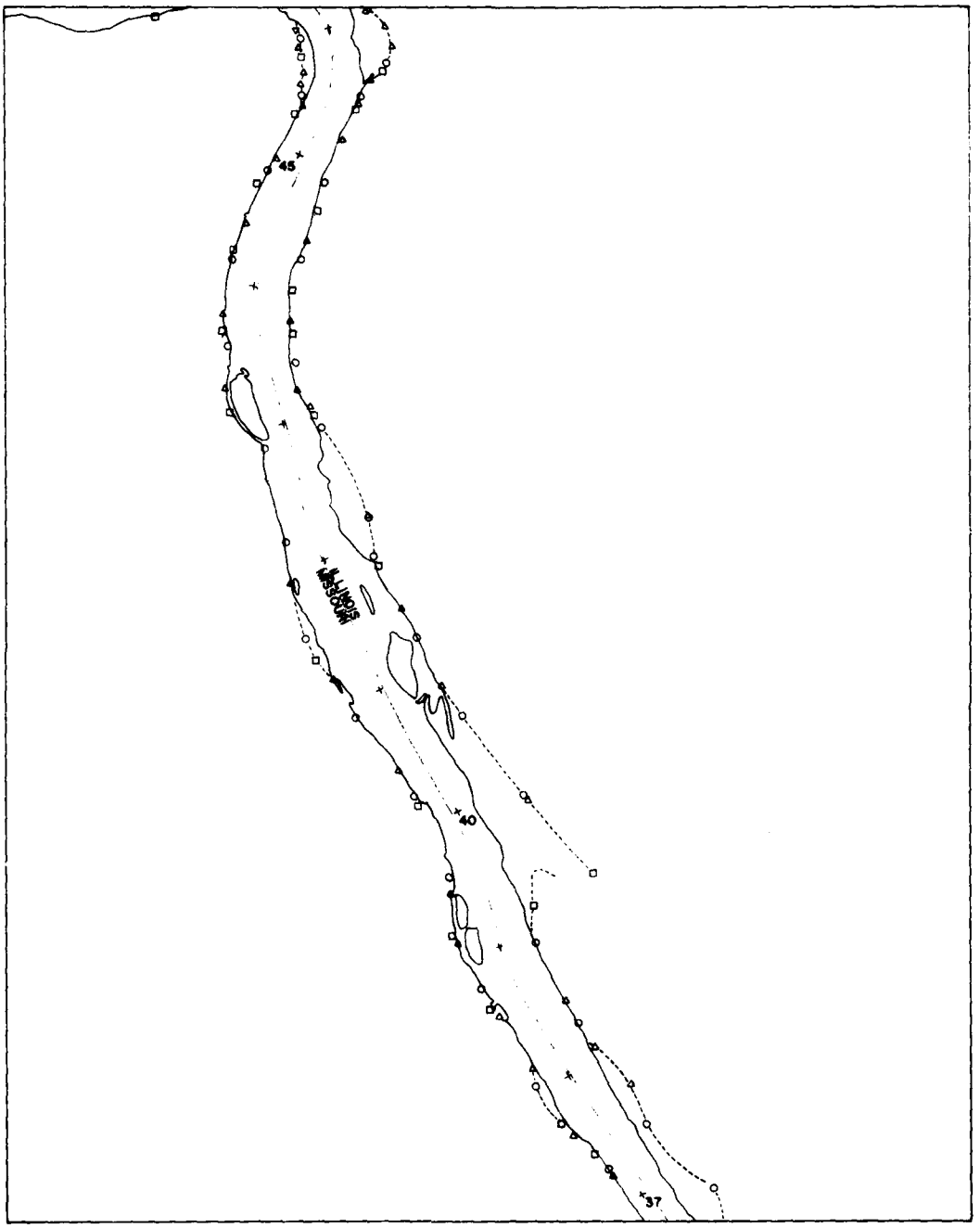


---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-56
○ - 1967-68
□ - 1975-76

THEBES SW QUADRANGLE
7.5 MINUTE SERIES
1967

1000' 0' 7000'

MAP 5

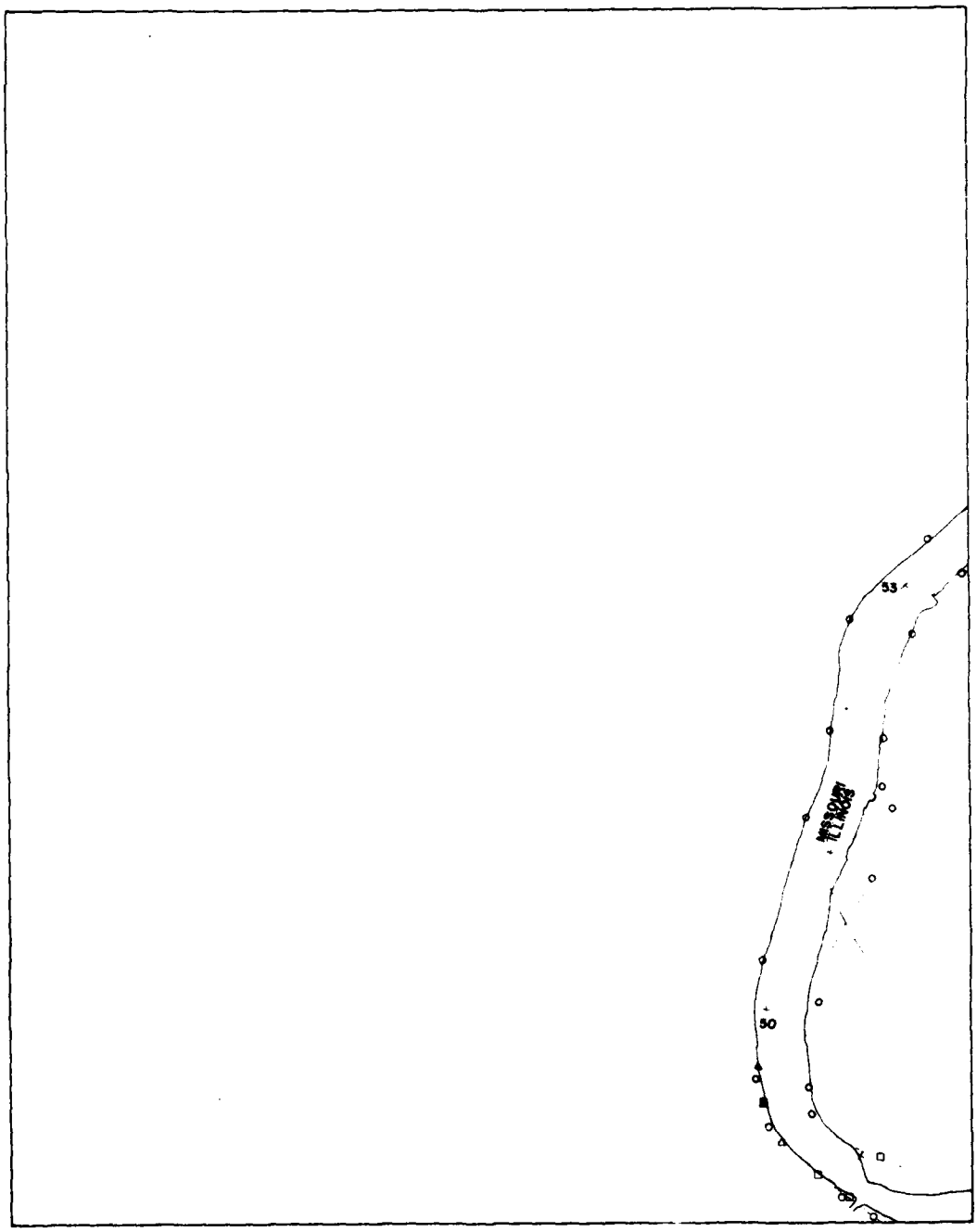


HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1953-58
○ – 1967-68
□ – 1975-78

THEBES QUADRANGLE
75 MINUTE SERIES
1966

1000' 0' 7000'

MAP 6

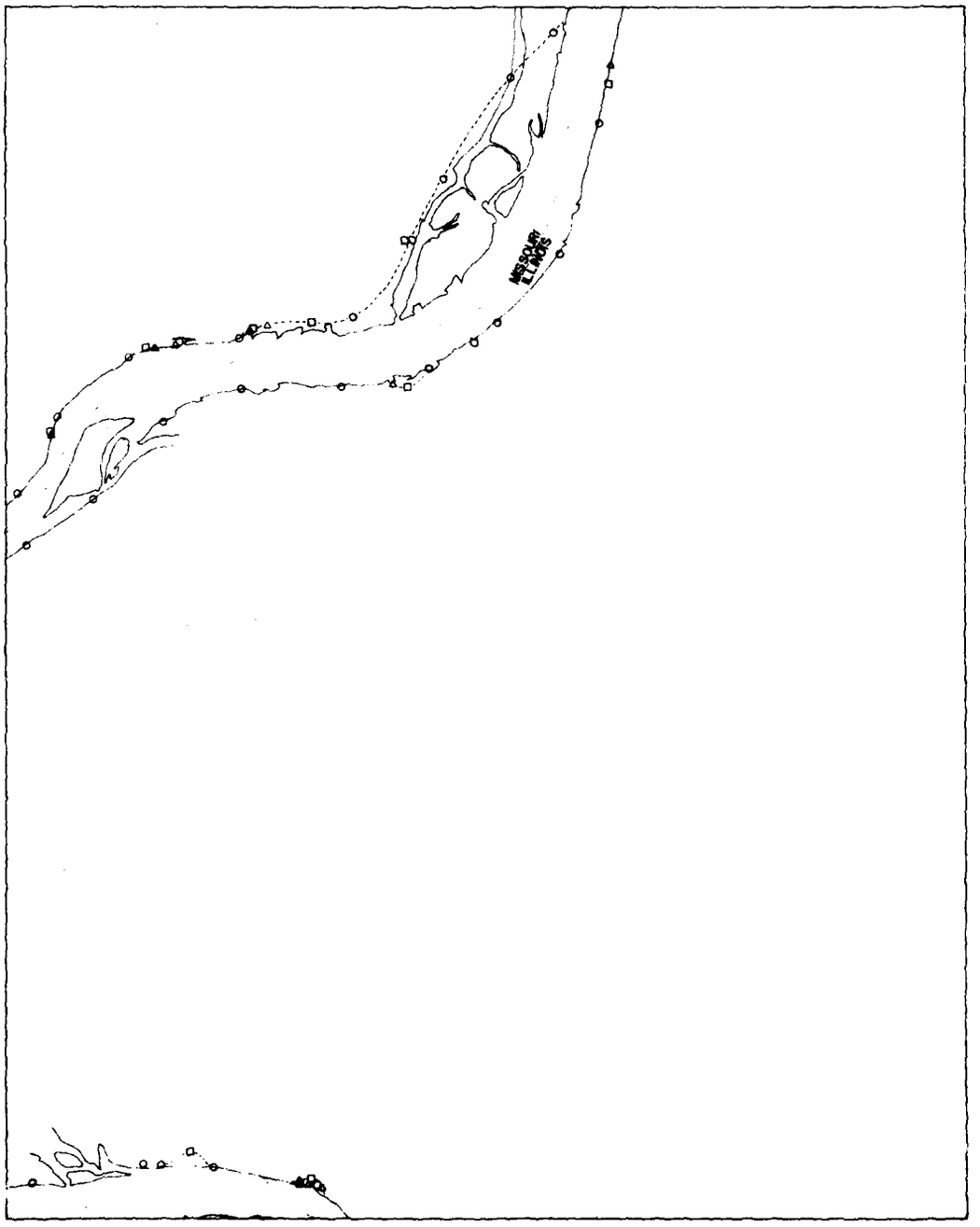


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-76

CAPE GIRARDEAU QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 7

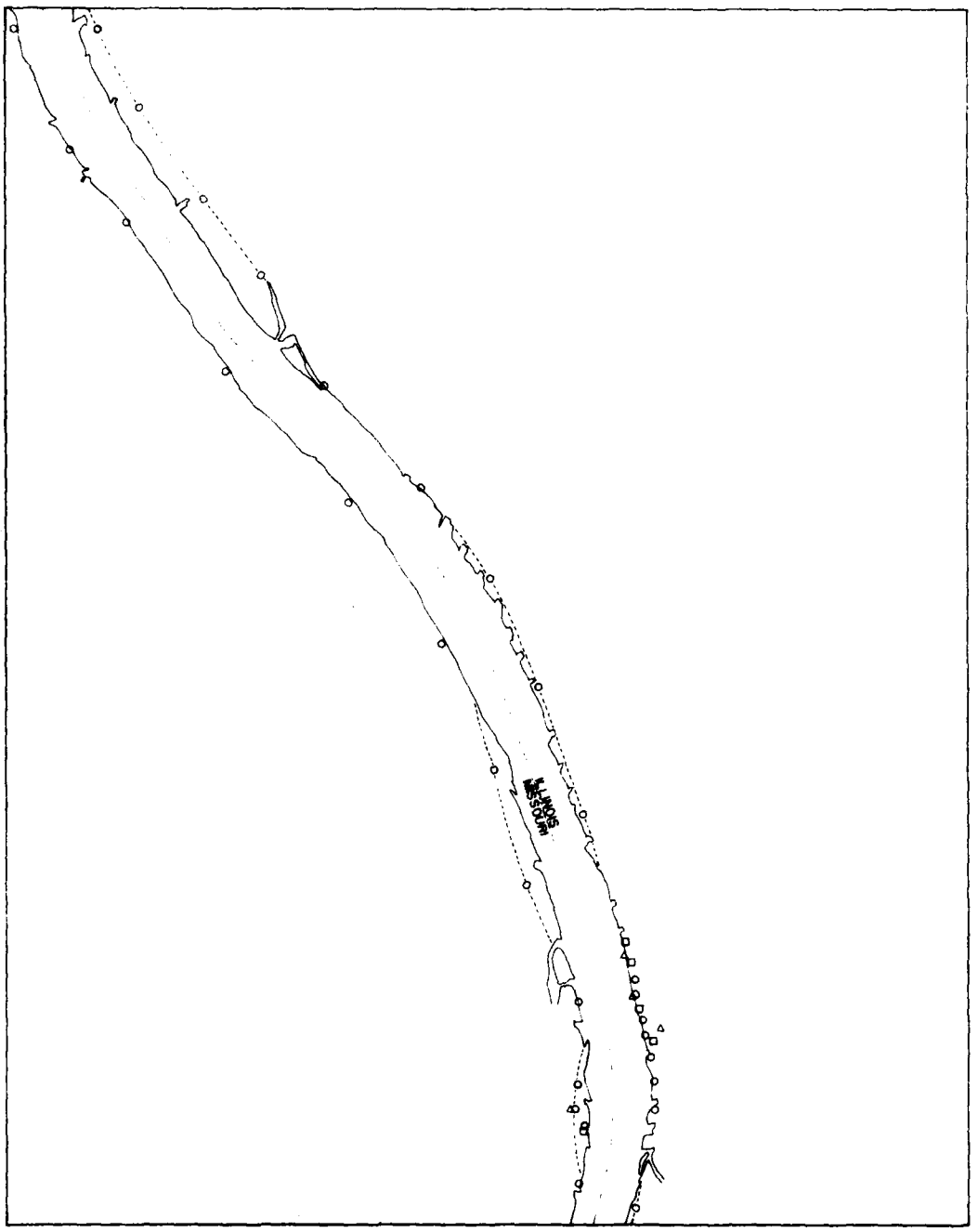


---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
Δ - 1953-58
o - 1967-68
□ - 1975-78

MC CLURE QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 8

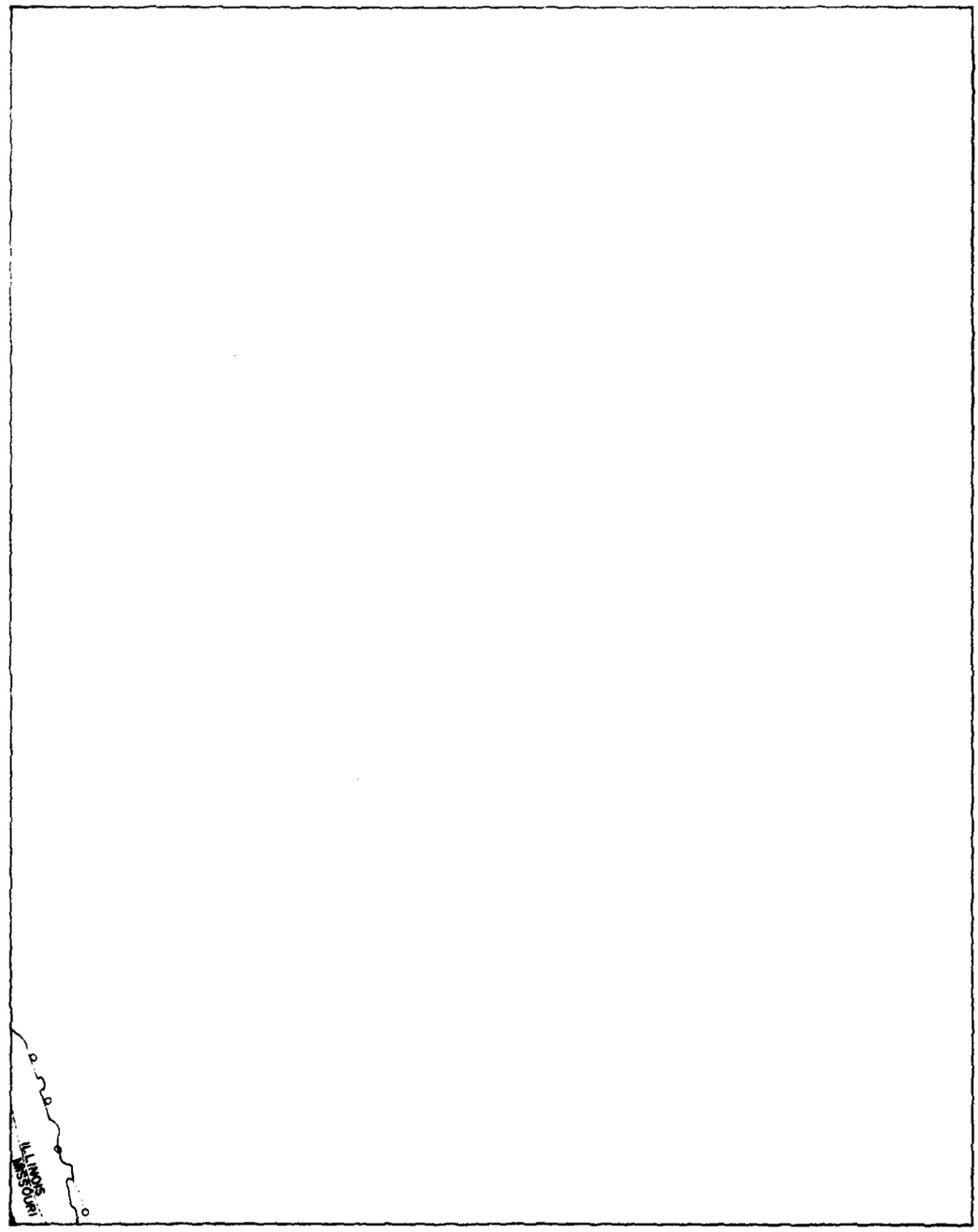


---- HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1953-58
○ – 1967-68
□ – 1975-76

WARE QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 9

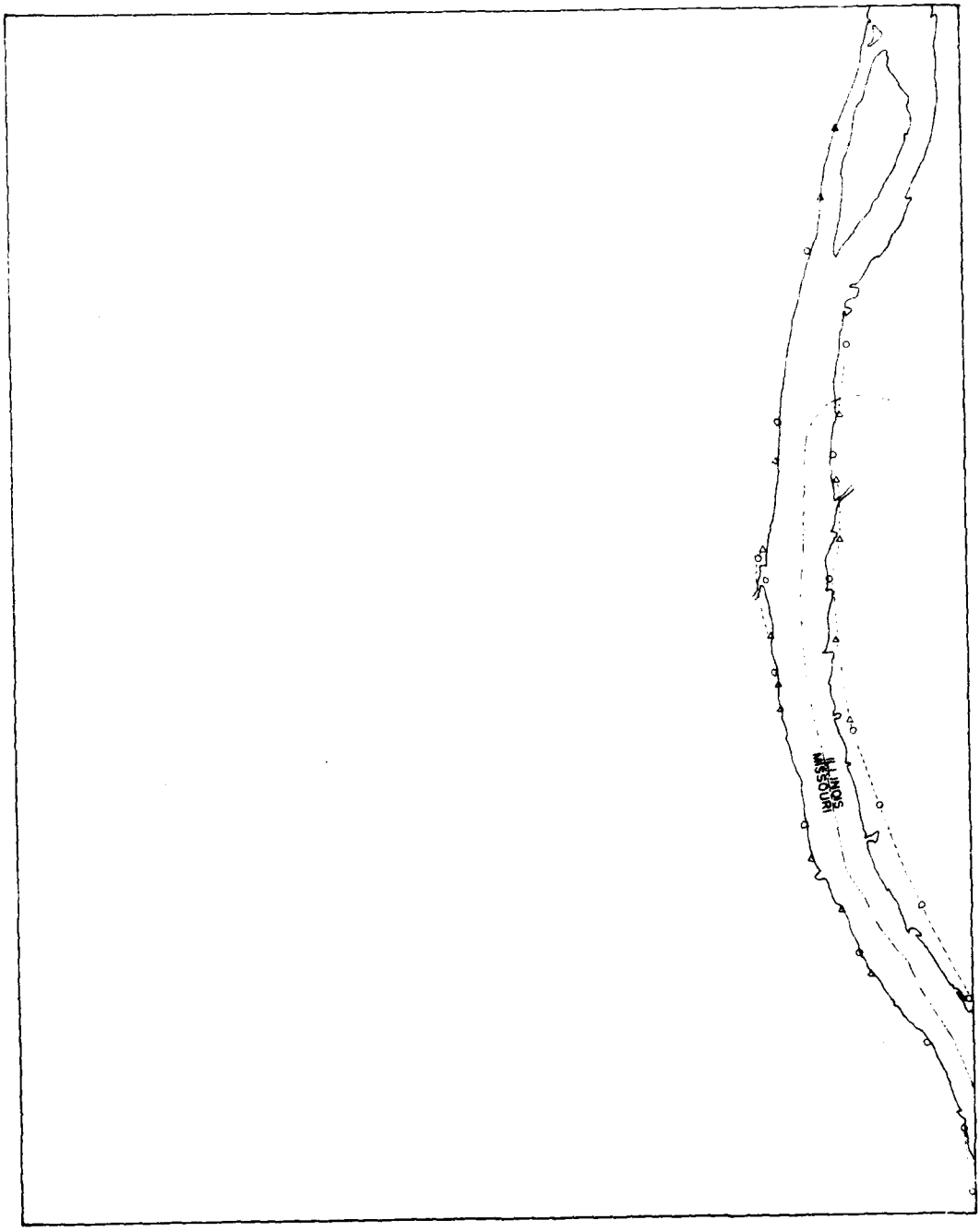


---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

WOLF LAKE QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 1000'

MAP 10

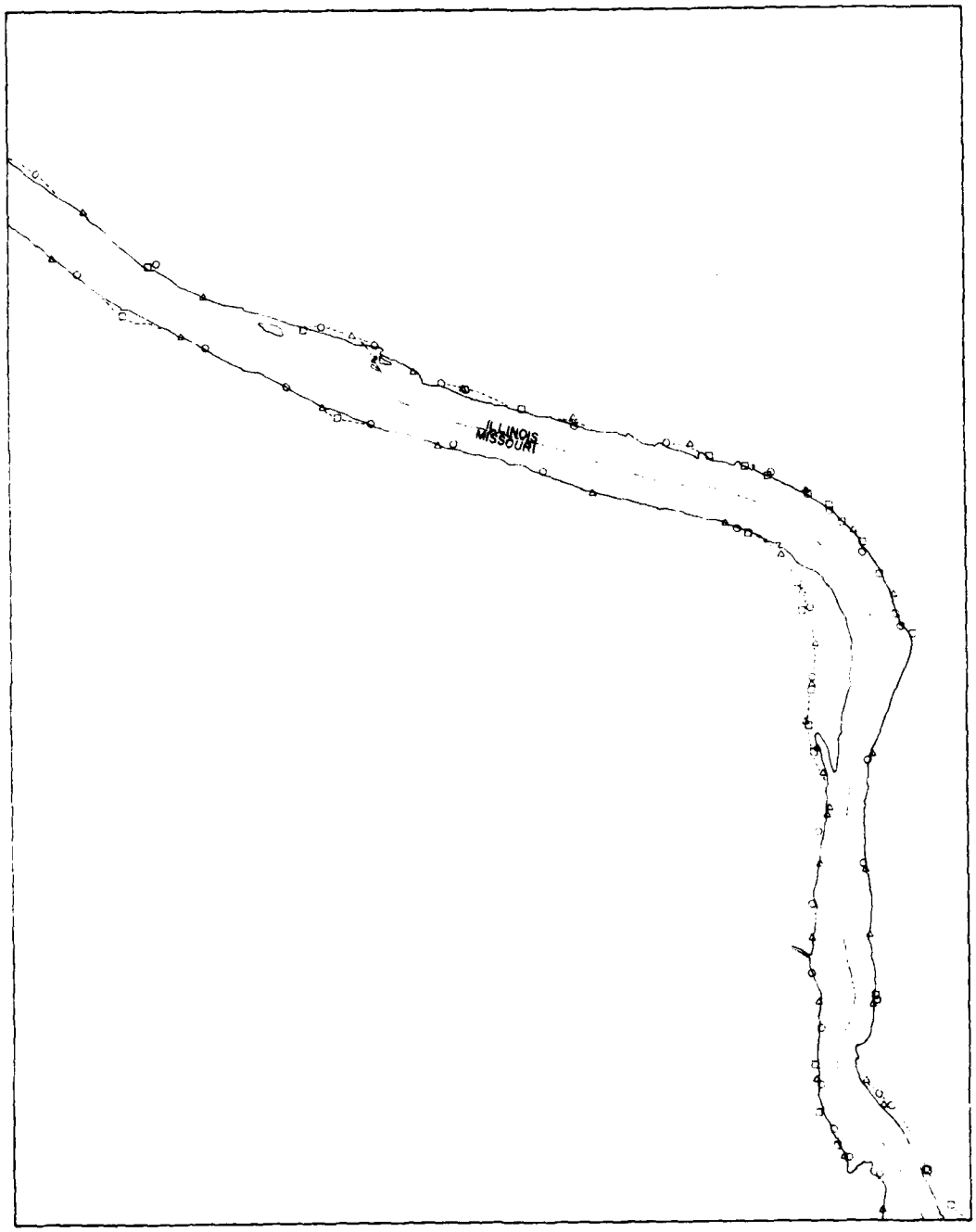


HIGH BANK LOCATION
× RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

NEELYS LANDING QUADRANGLE
75 MINUTE SERIES
1978

1000' 0' 7000'

MAP II

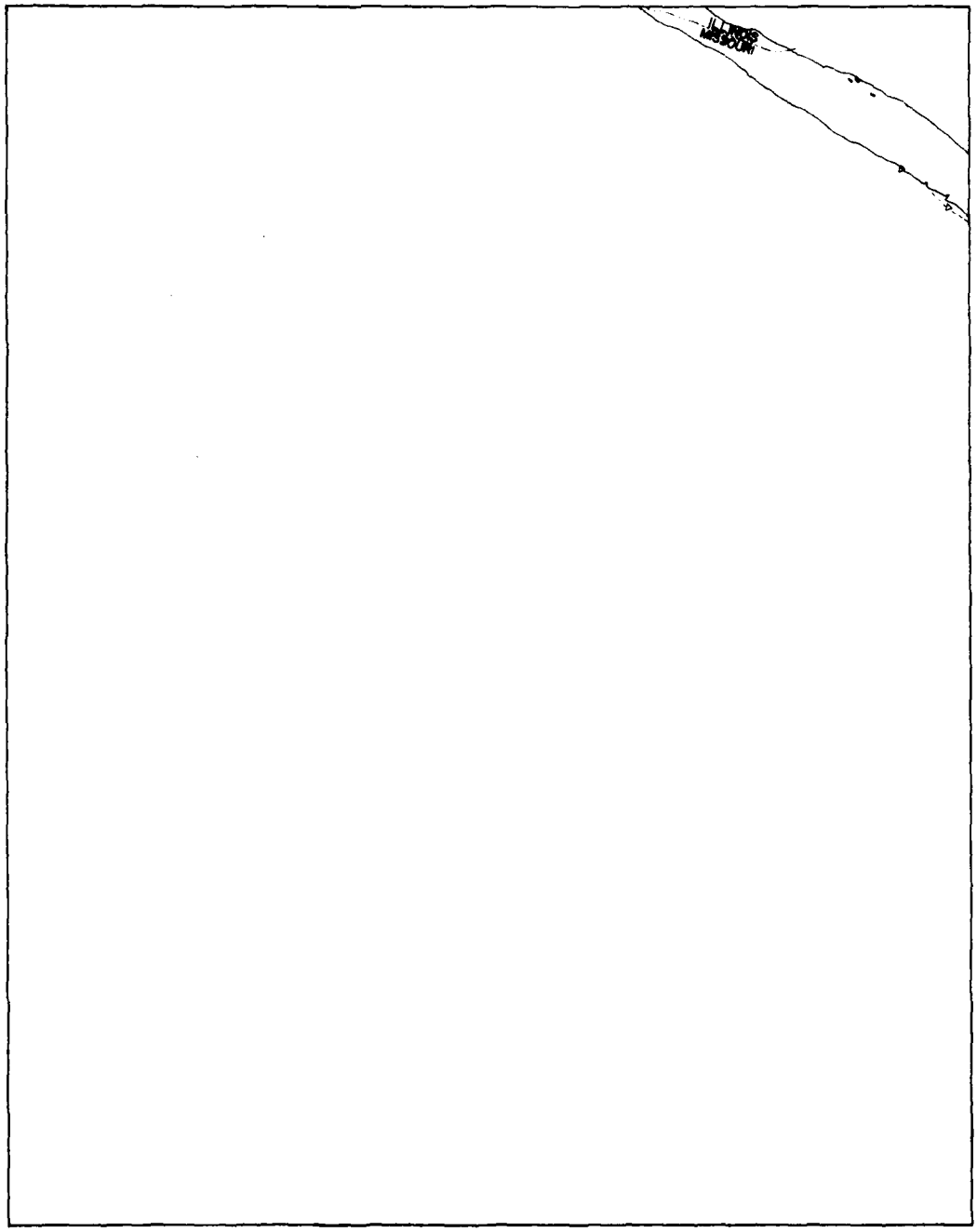


---- HIGH BANK LOCATION
x -- RIVER MILE
RESECTION POINTS
Δ - 1953-58
o - 1967-68
□ - 1975-78

ALTENBURG QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 12

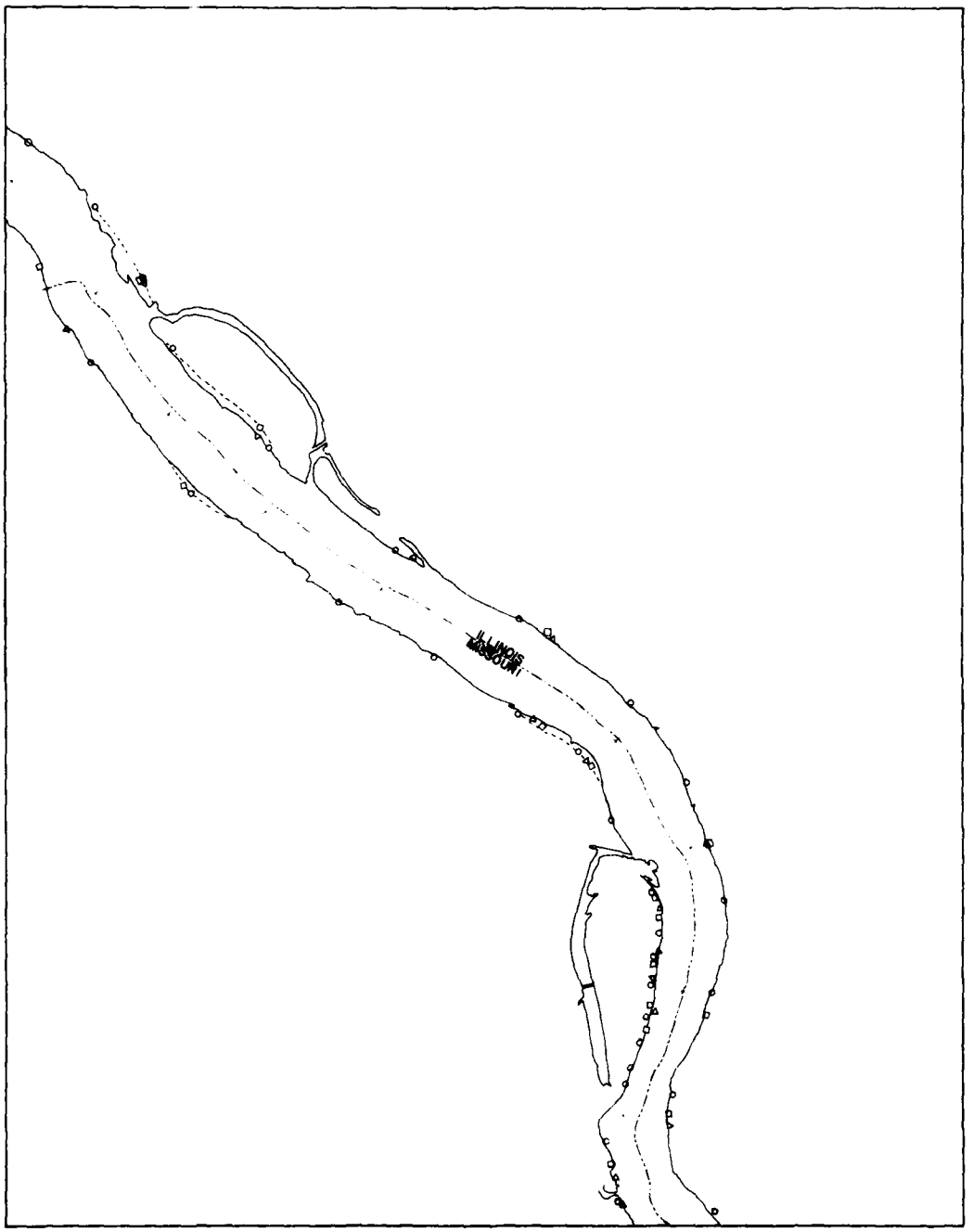


···· HIGH BANK LOCATION
× RIVER MILE
RESECTION POINTS
△ - 1955-58
○ - 1967-68
□ - 1975-78

CROSSTOWN QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 13

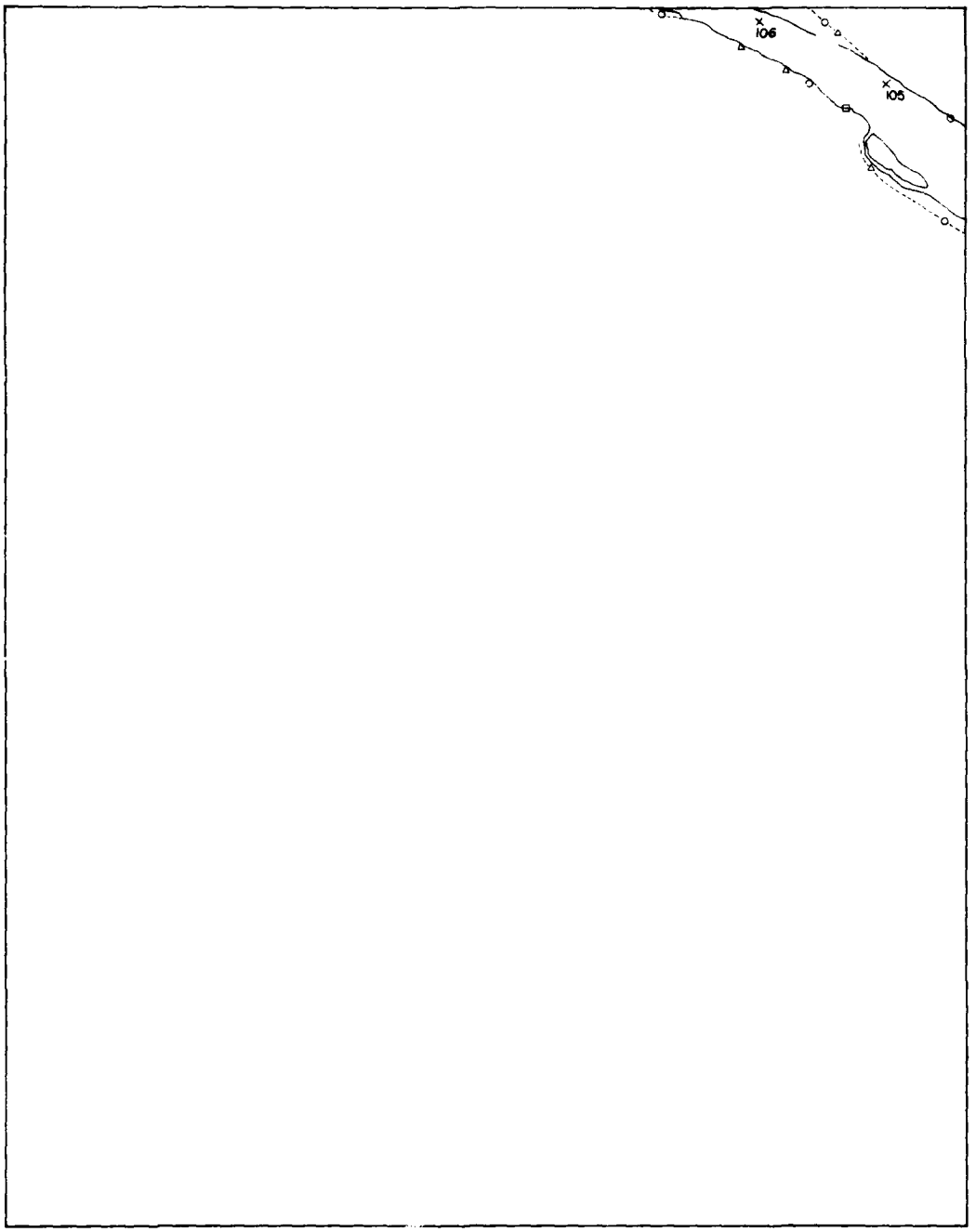


HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ 1967-68
□ 1975-78

ROCKWOOD QUADRANGLE
7.5 MINUTE SERIES
1968

1000' 0' 7000'

MAP 14

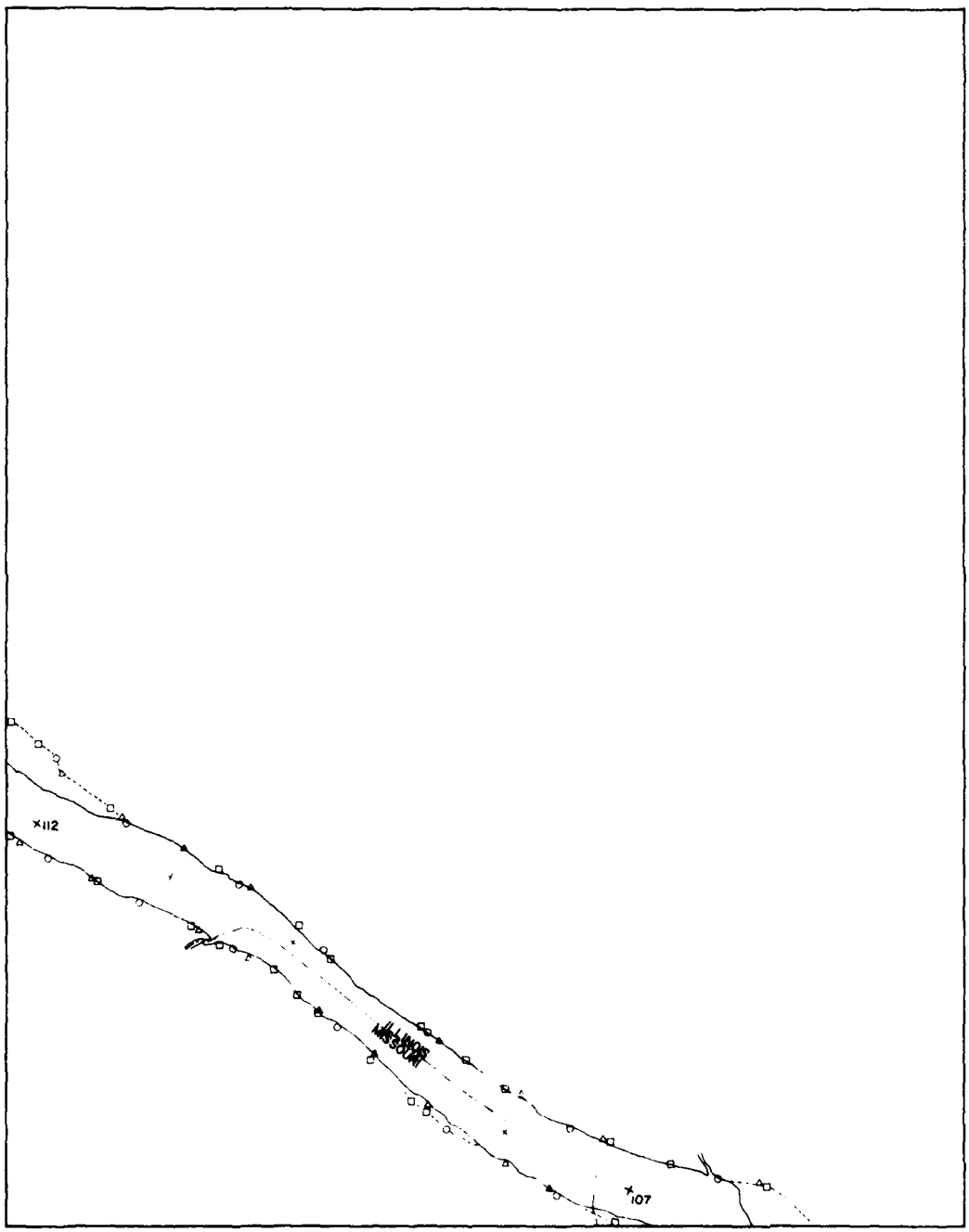


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

BELGIQUE QUADRANGLE
7.5 MINUTE SERIES
1970

1000' 0' 7000'

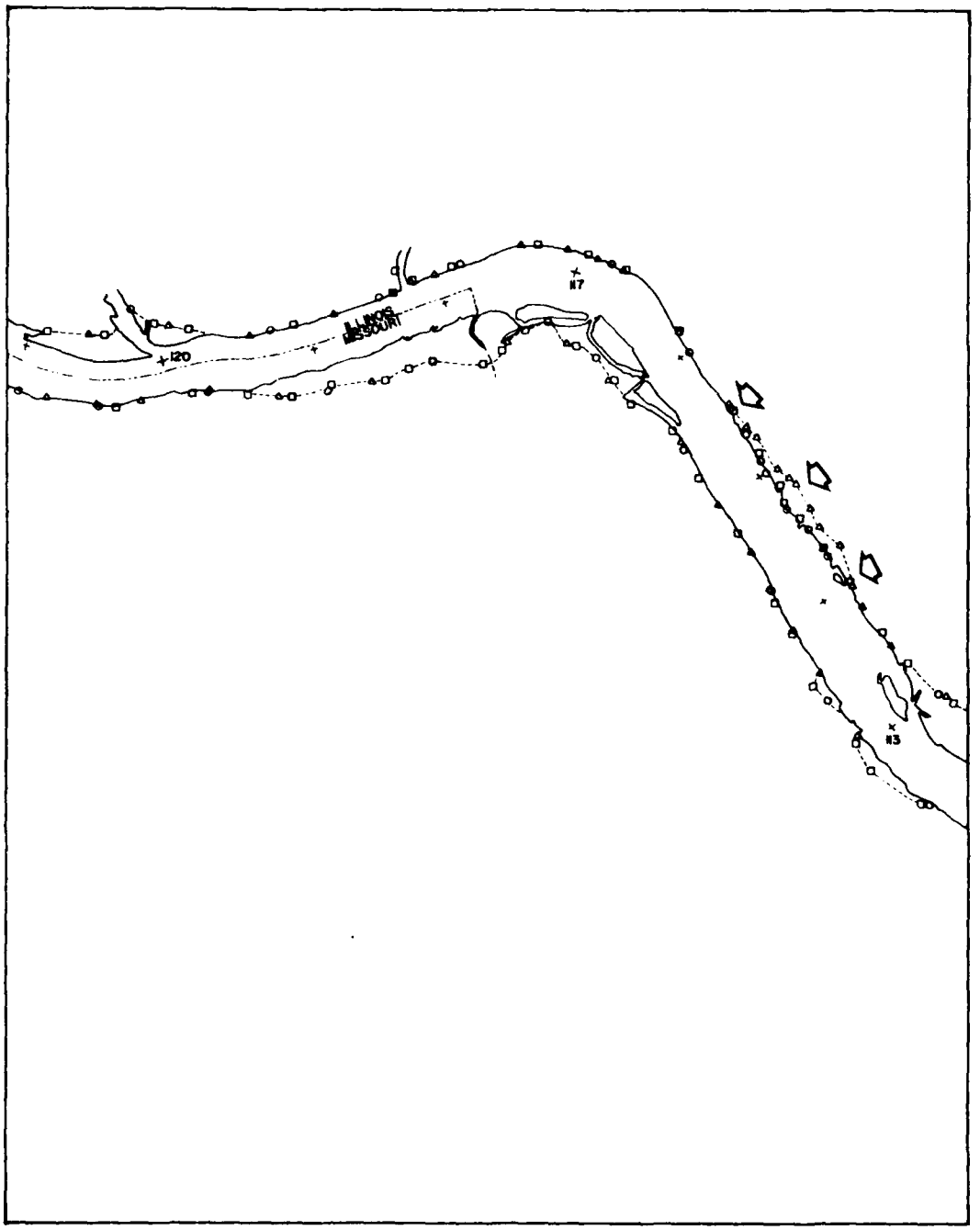
MA › 15



HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-76

CHESTER QUADRANGLE
75 MINUTE SERIES
1970
1000' 0' 7000'

MAP 16

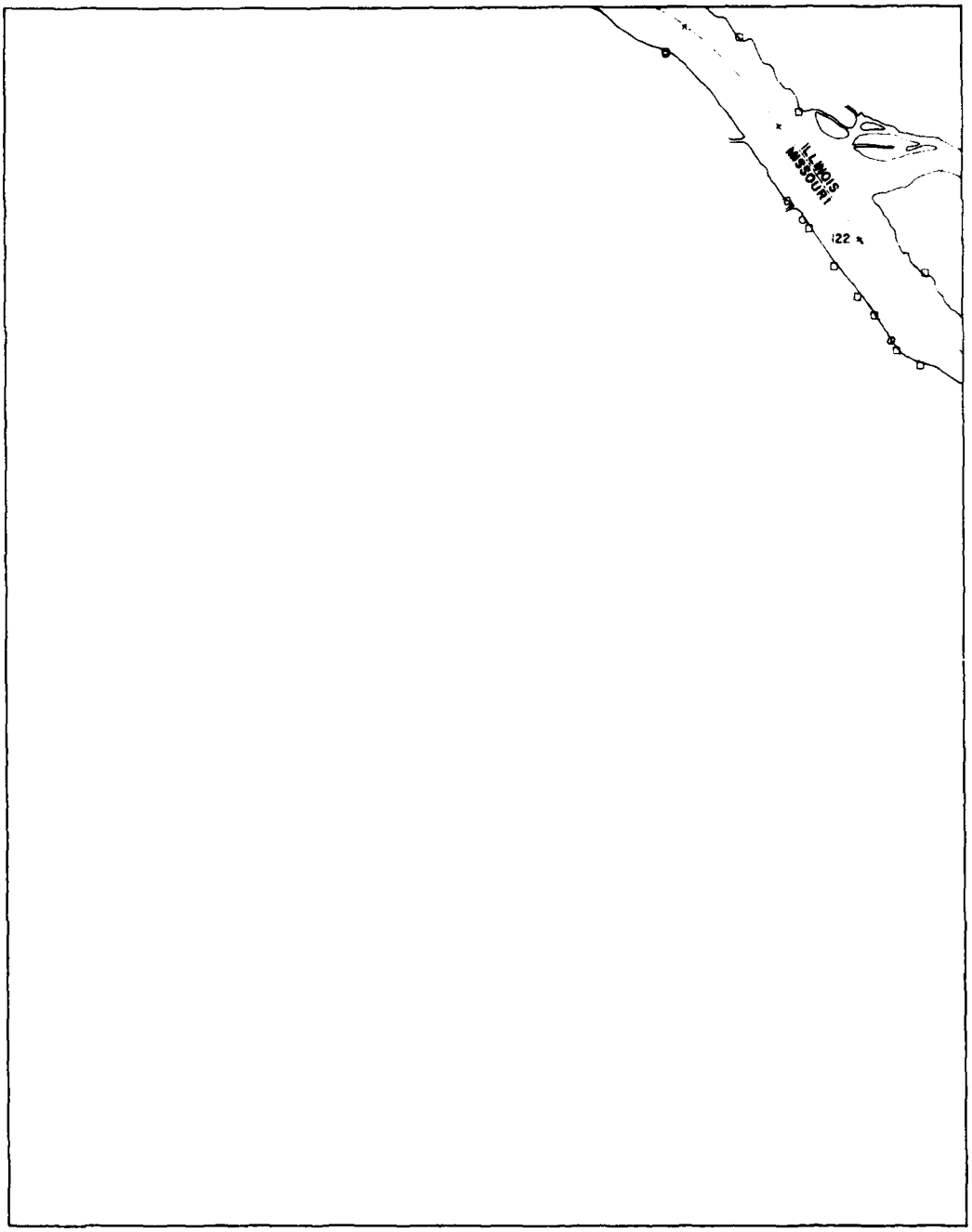


---- HIGH BANK LOCATION
x — RIVER MILE
RESECTION POINTS
▲ — 1953-56
○ — 1967-68
□ — 1975-78

KASKASKIA QUADRANGLE
7.5 MINUTE SERIES
1970

1000' 0' 7000'

MAP 17

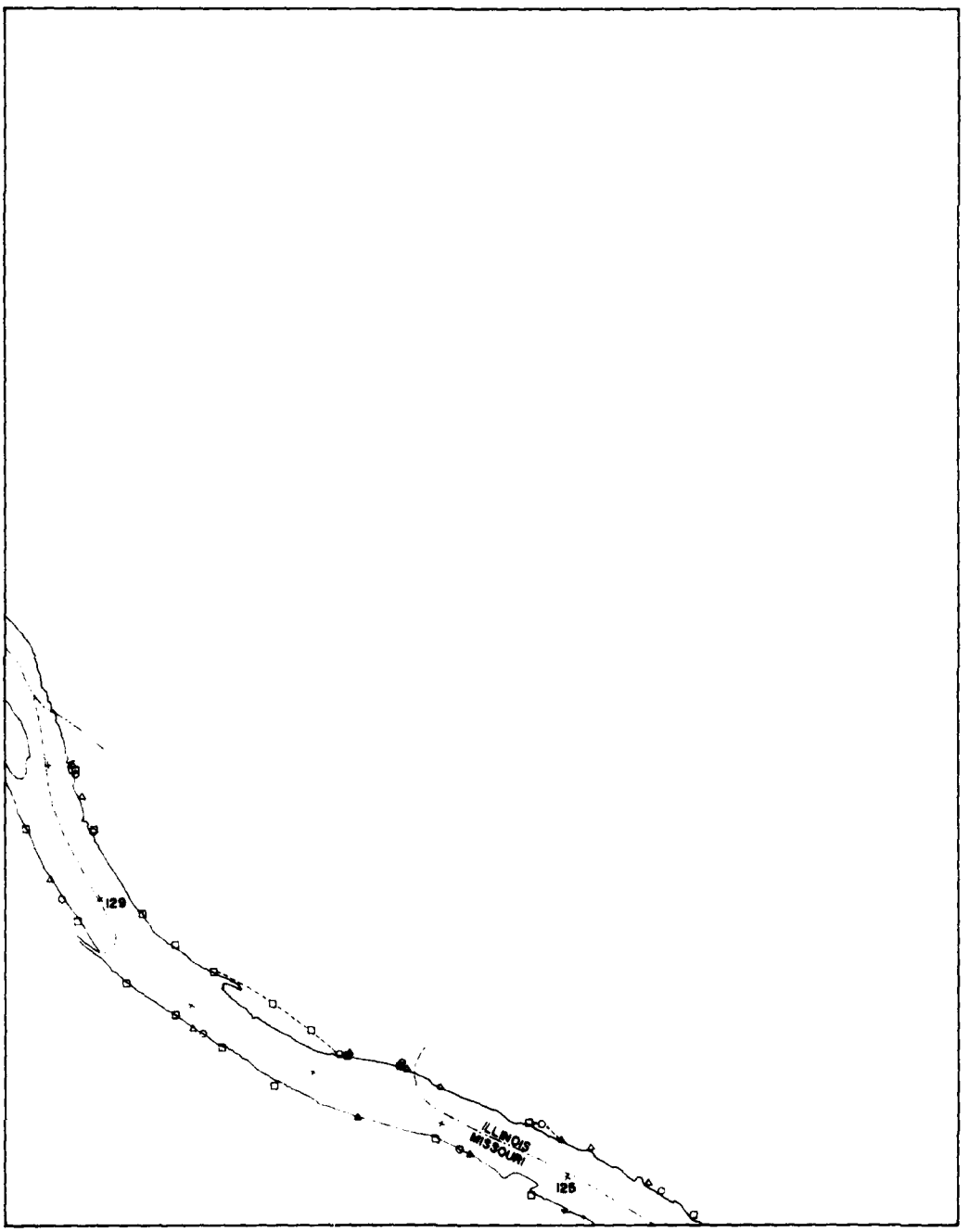


---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
▵ - 1953-58
○ - 1967-68
□ - 1975-78

STE GENEVIEVE QUADRANGLE
75 MINUTE SERIES
1979

1000' 0' 7000'

MAP 18

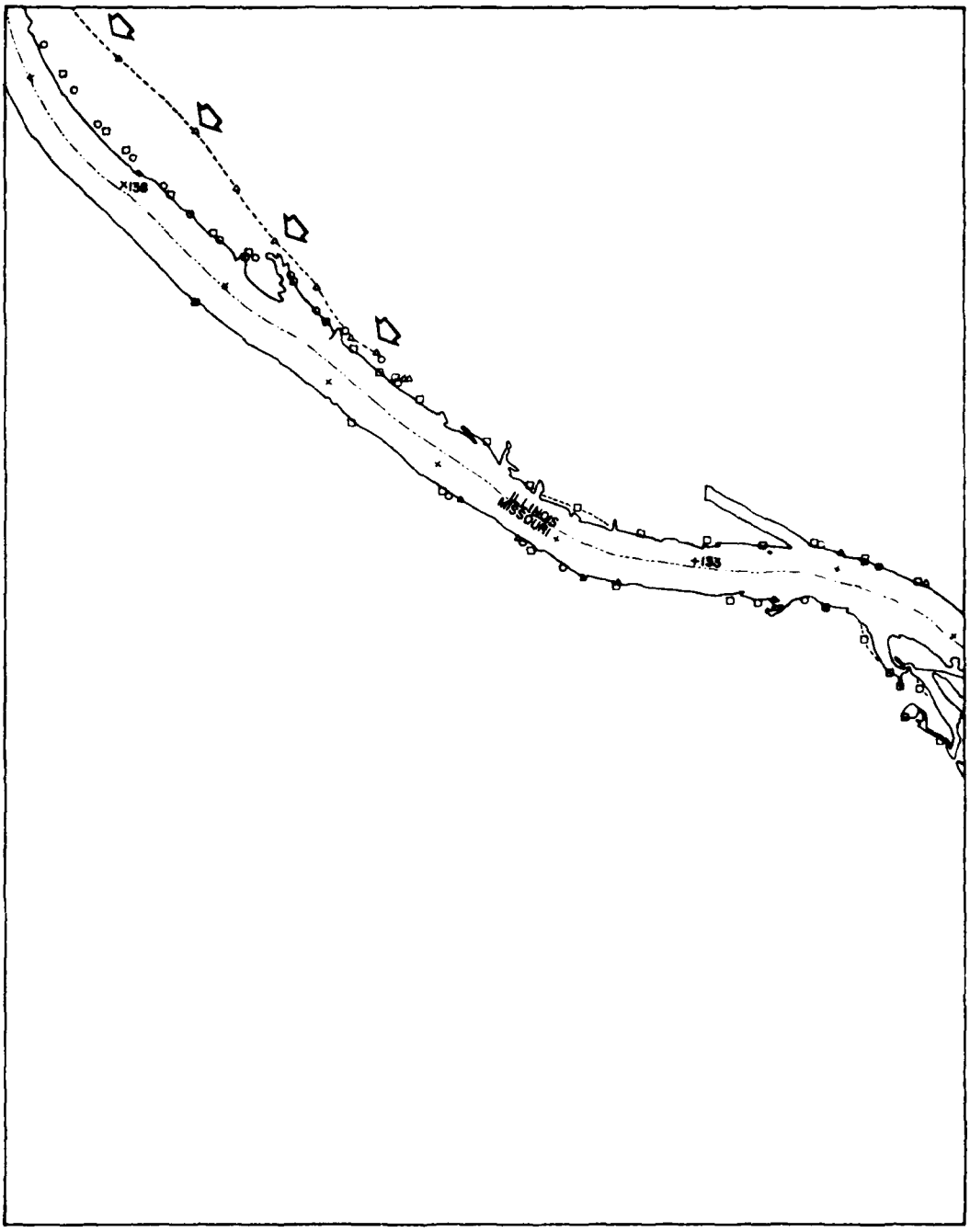


HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1963-68
○ - 1967-68
□ - 1975-78

PRAIRIE DU ROCHER QUADRANGLE
7.5 MINUTE SERIES
1970

1000' 0' 7000'

MAP 19

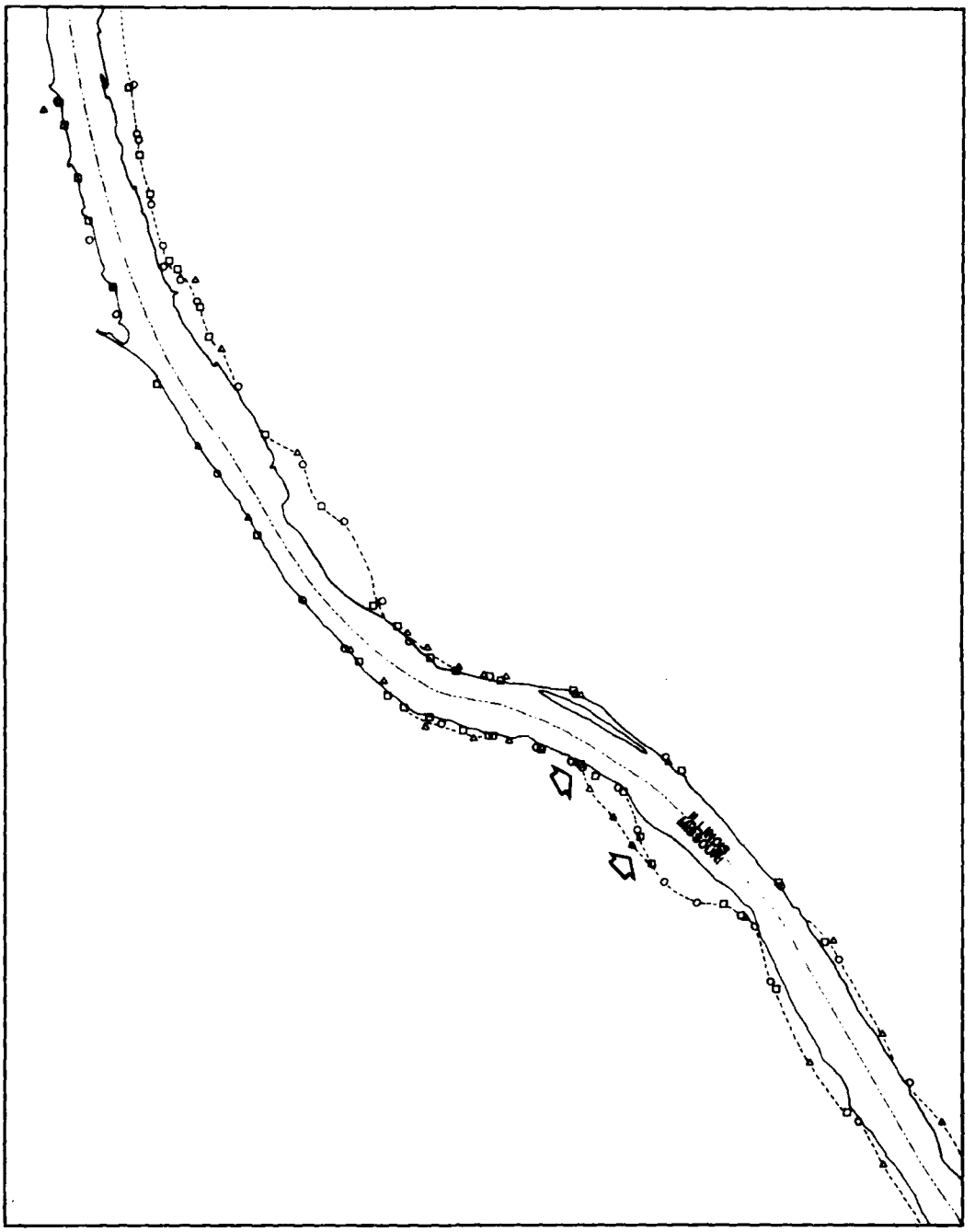


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
▲ - 1853-98
○ - 1967-68
□ - 1975-78

BLOOMSDALE QUADRANGLE
7.5 MINUTE SERIES
1970

1000' 0' 7000'

MAP 20

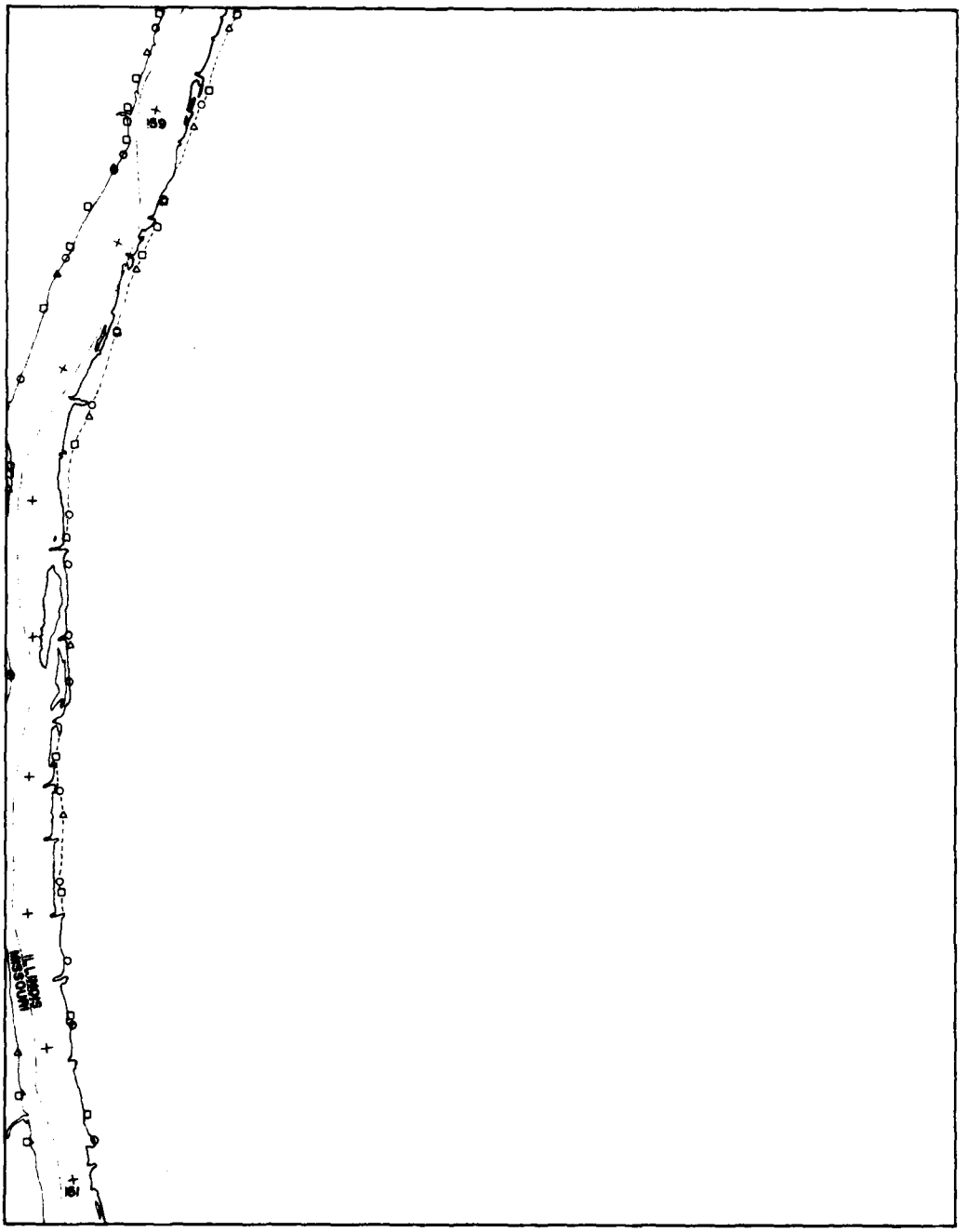


— HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1963-66
○ – 1967-68
□ – 1975-76

SELMA QUADRANGLE
75 MINUTE SERIES
1964

1000' 0' 7000'

MAP 21

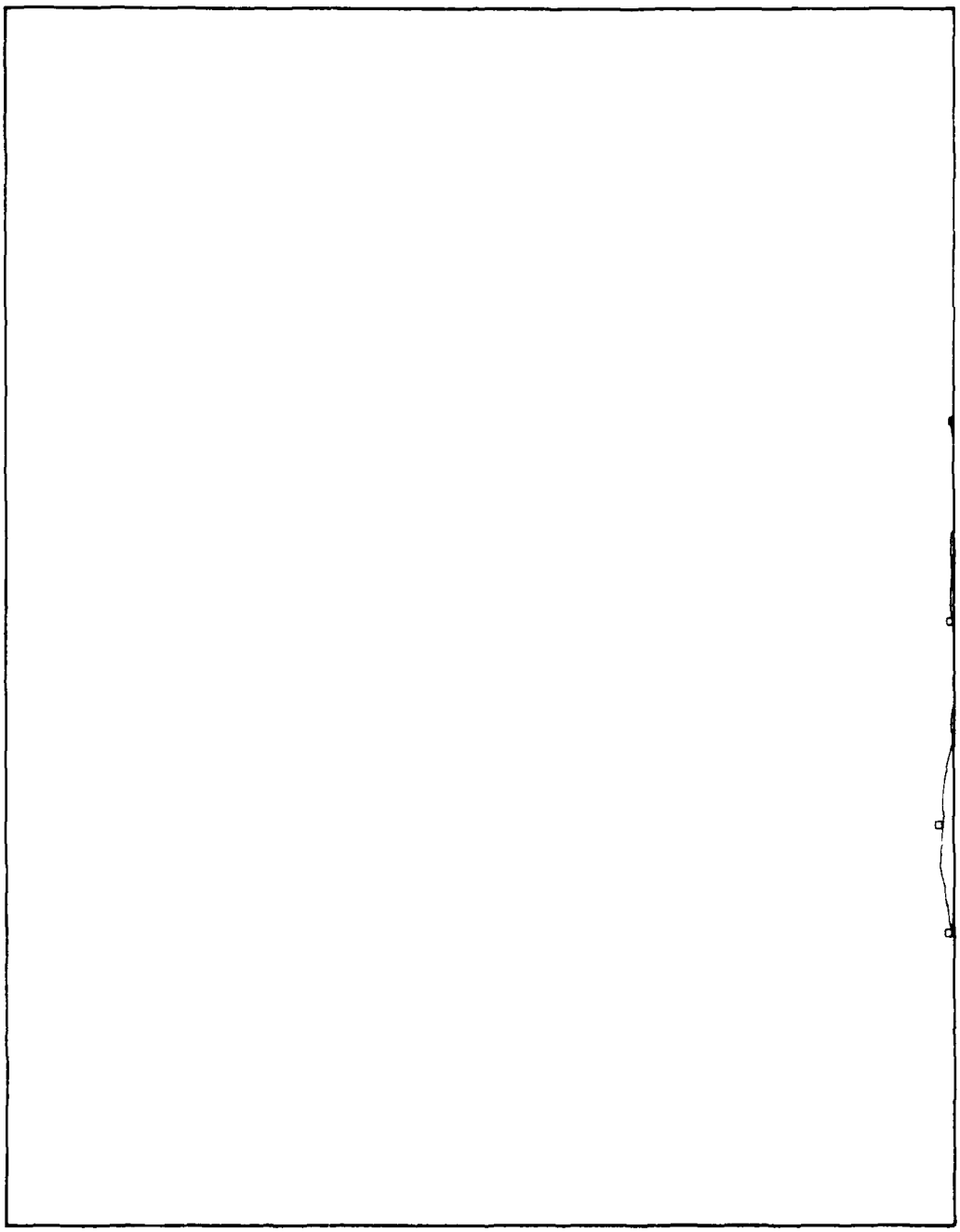


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-56
○ - 1967-68
□ - 1975-76

VALMEYER QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 7000'

MAP 22

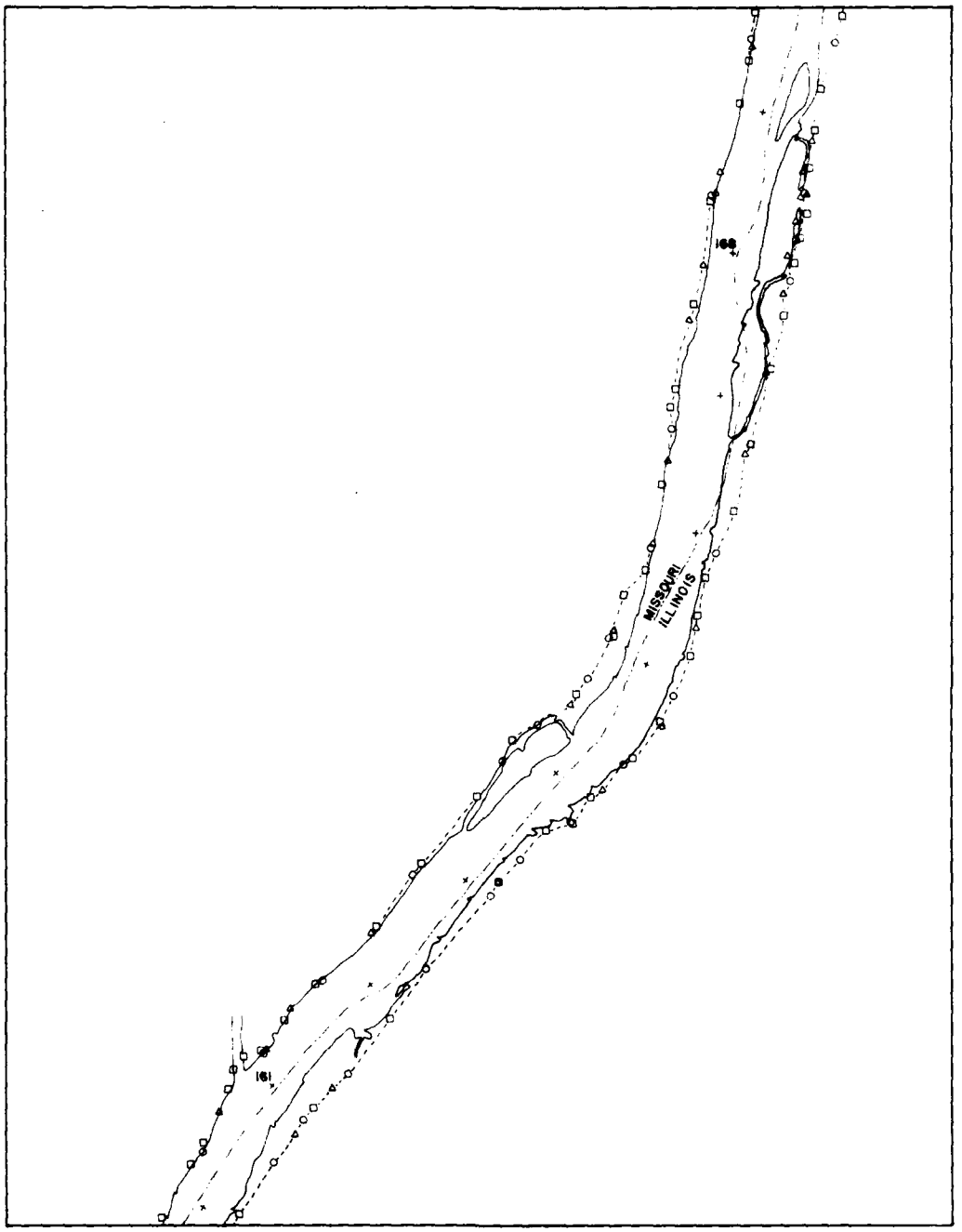


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1963-66
○ - 1967-68
□ - 1975-76

HERCULANEUM QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 7000'

MAP 23

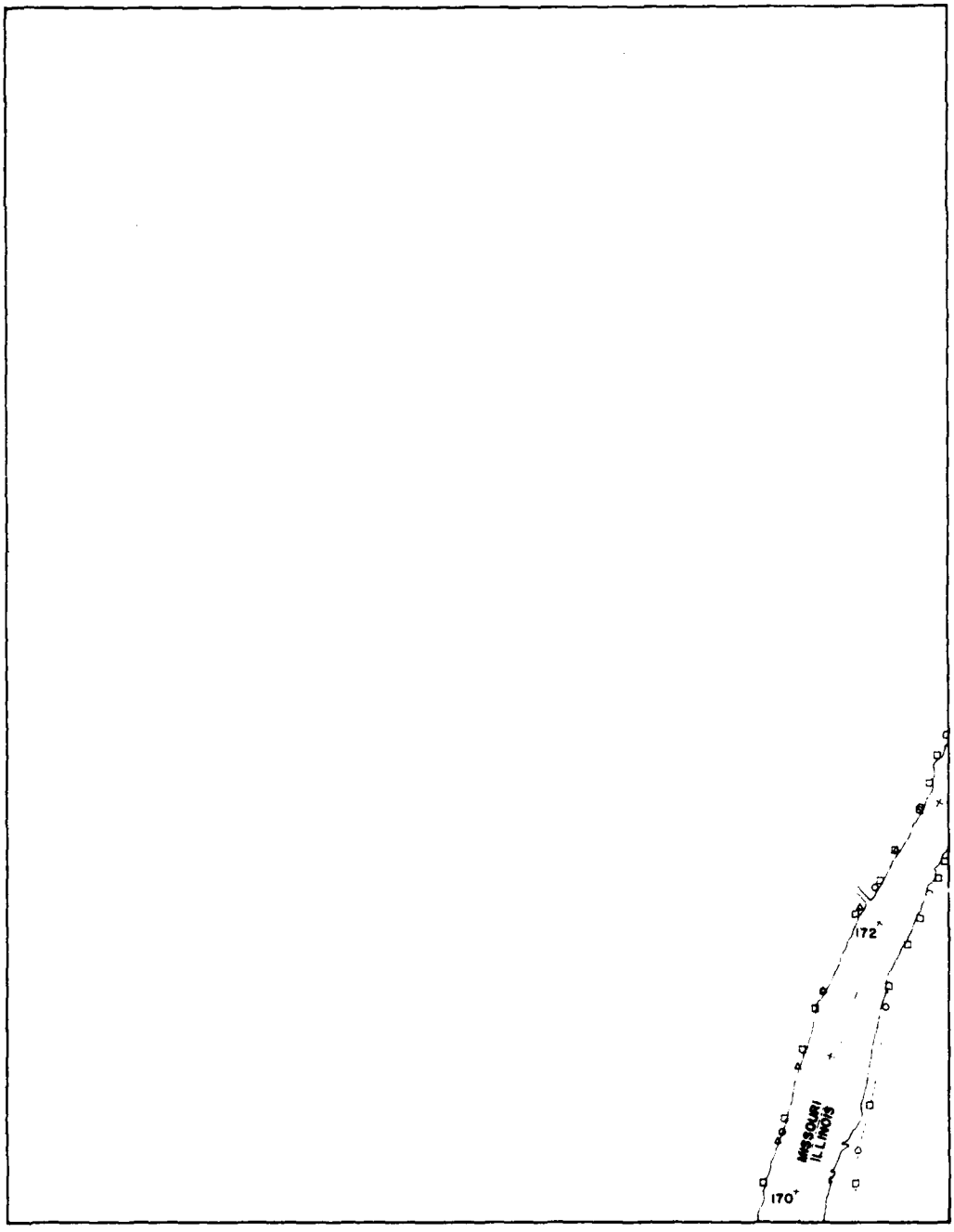


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-56
○ - 1967-68
□ - 1975-76

OAKVILLE QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 7000'

MAP 24

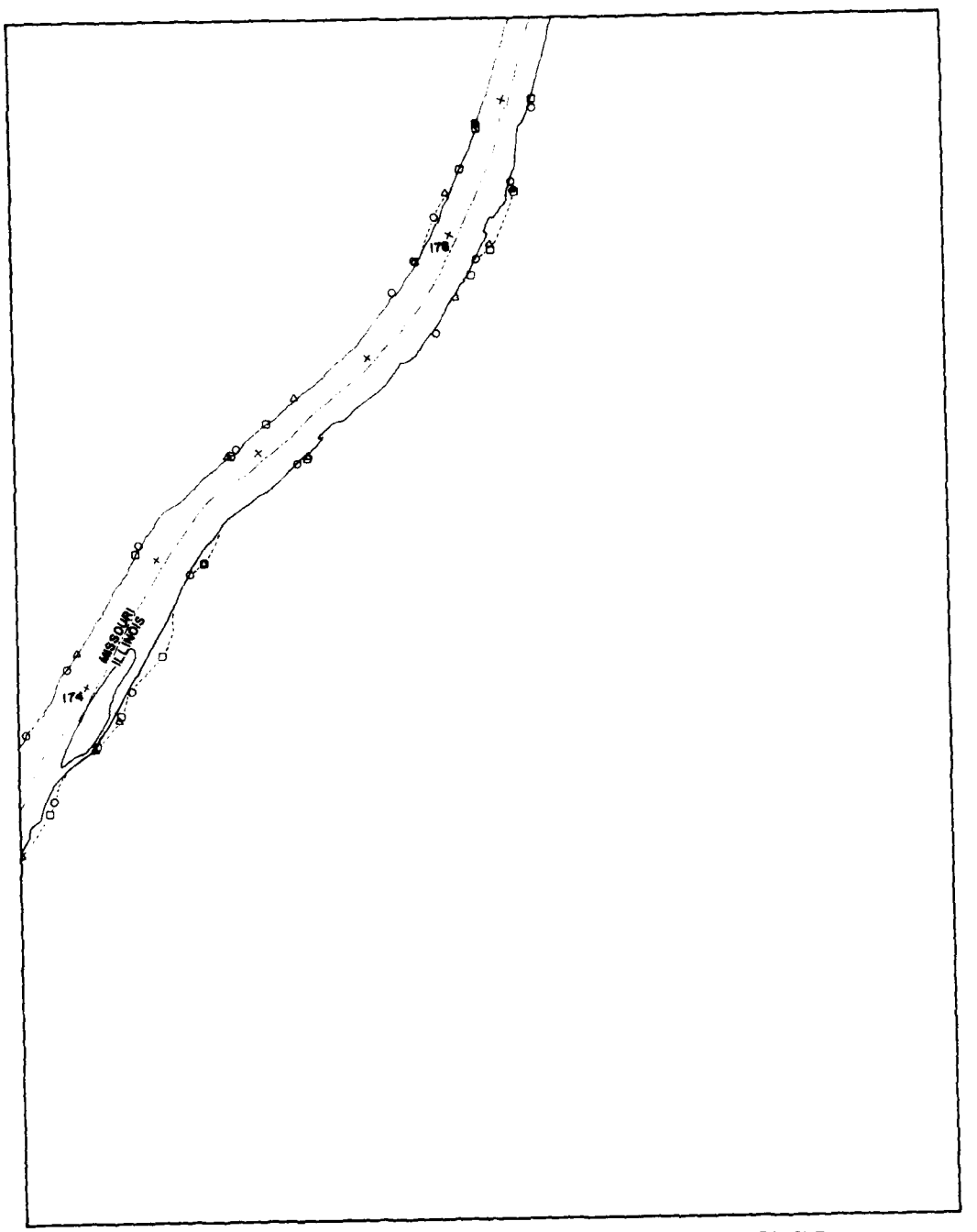


HIGH BANK LOCATION
× RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

WEBSTER GROVES QUADRANGLE
75 MINUTE SERIES
1974

1000' 0' 7000'

MAP 25

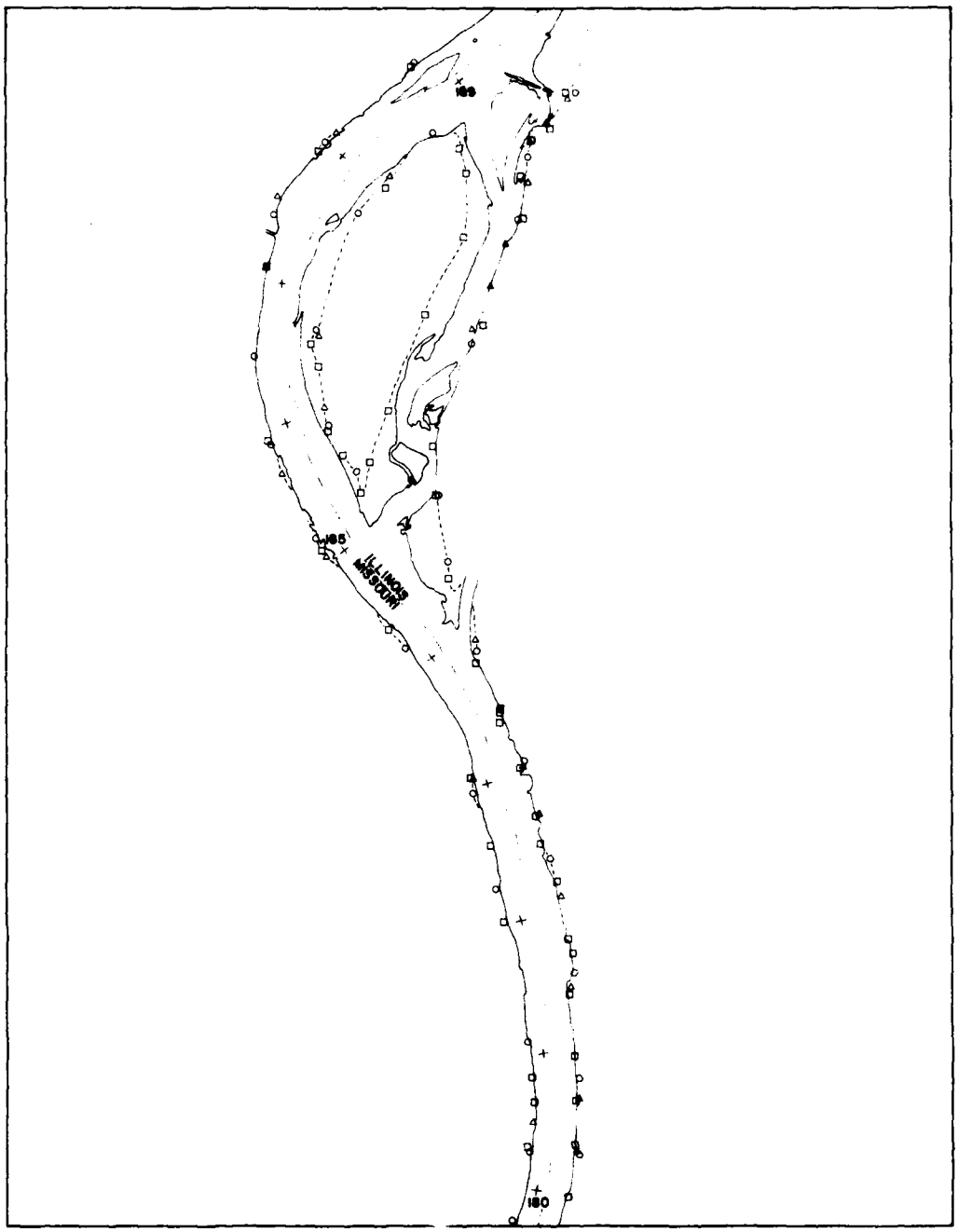


..... HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1963-68
○ - 1967-68
□ - 1975-78

CAHOKIA QUADRANGLE
75 MINUTE SERIES
1974

1000' 0' 1000'

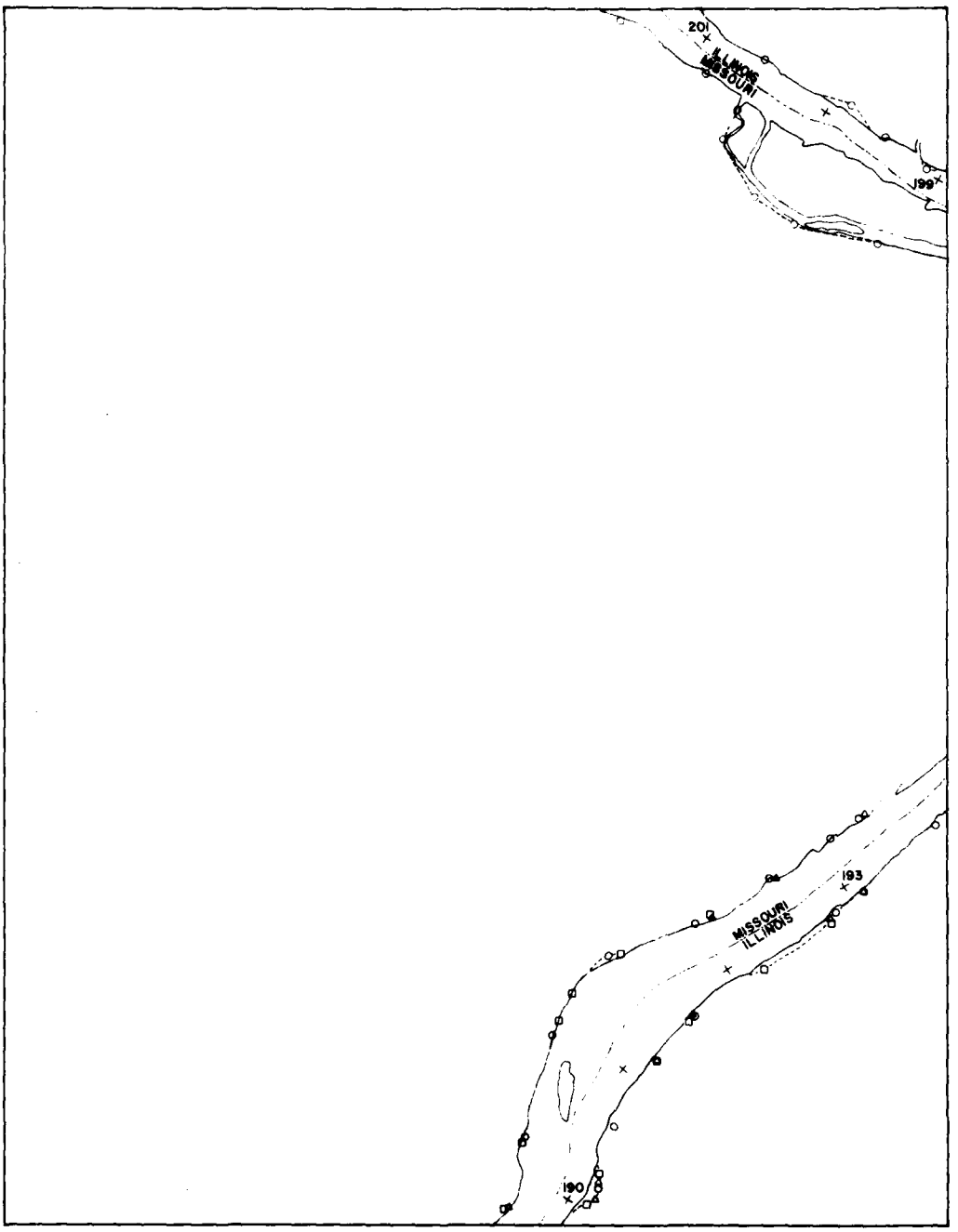
MAP 26



--- HIGH BANK LOCATION
x – RIVER MILE
RESECTION POINTS
△ – 1953-56
○ – 1967-68
□ – 1975-76

GRANITE CITY QUADRANGLE
7.5 MINUTE SERIES
1974
1000' 0' 7000'

MAP 27

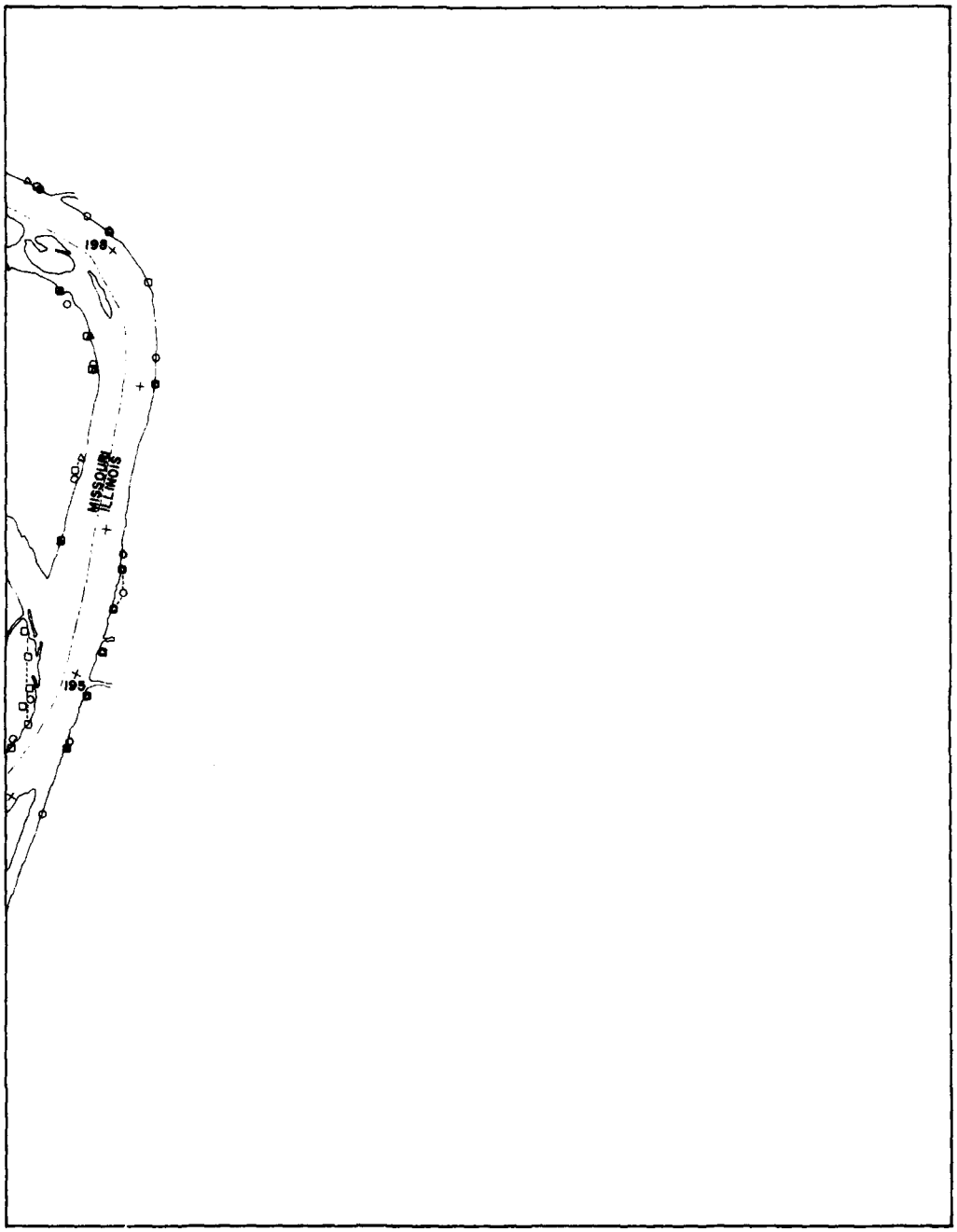


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1963-66
○ - 1967-68
□ - 1975-76

COLUMBIA BOTTOM QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 7000'

MAP 28

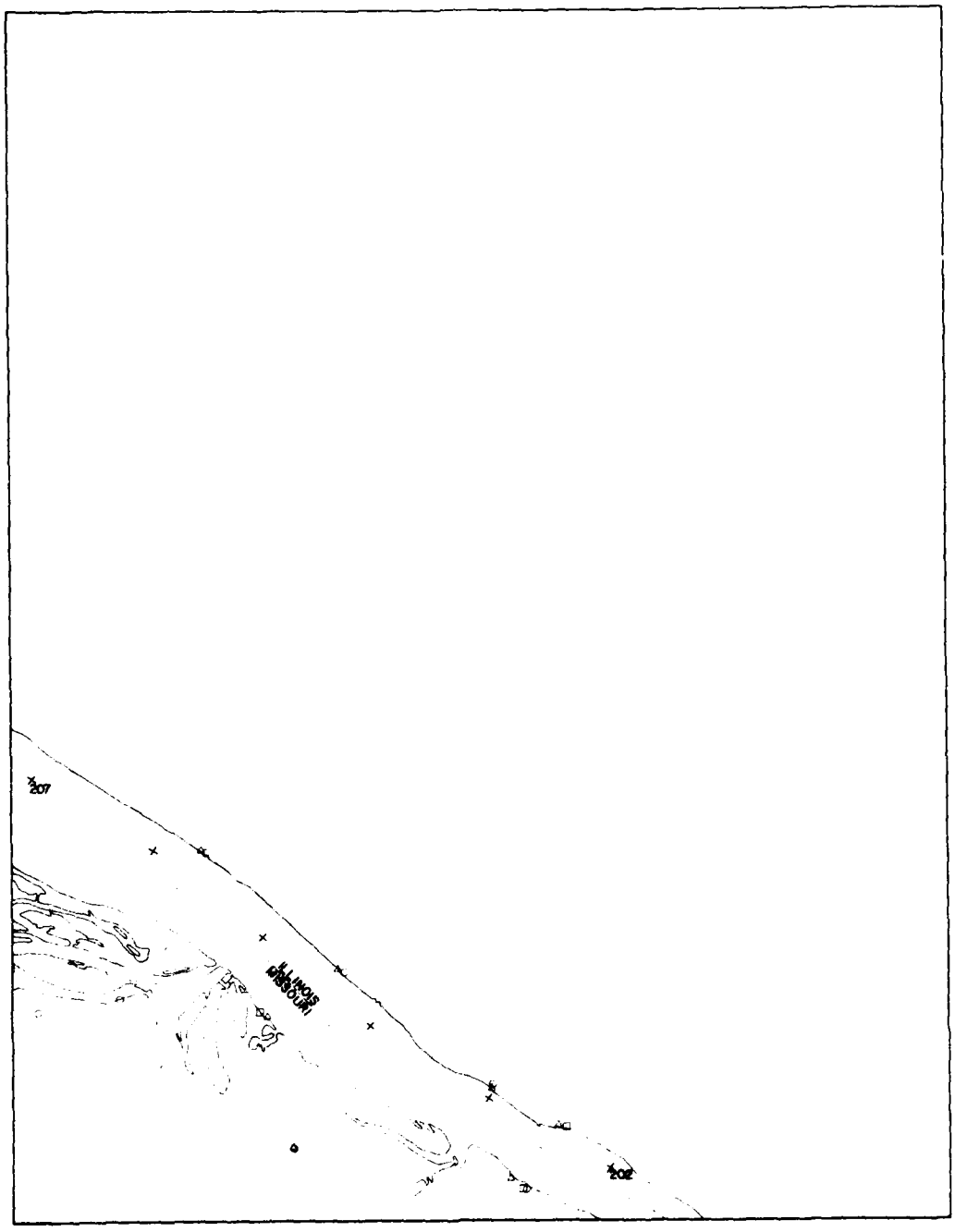


---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-76

WOOD RIVER QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 7000'

MAP 29

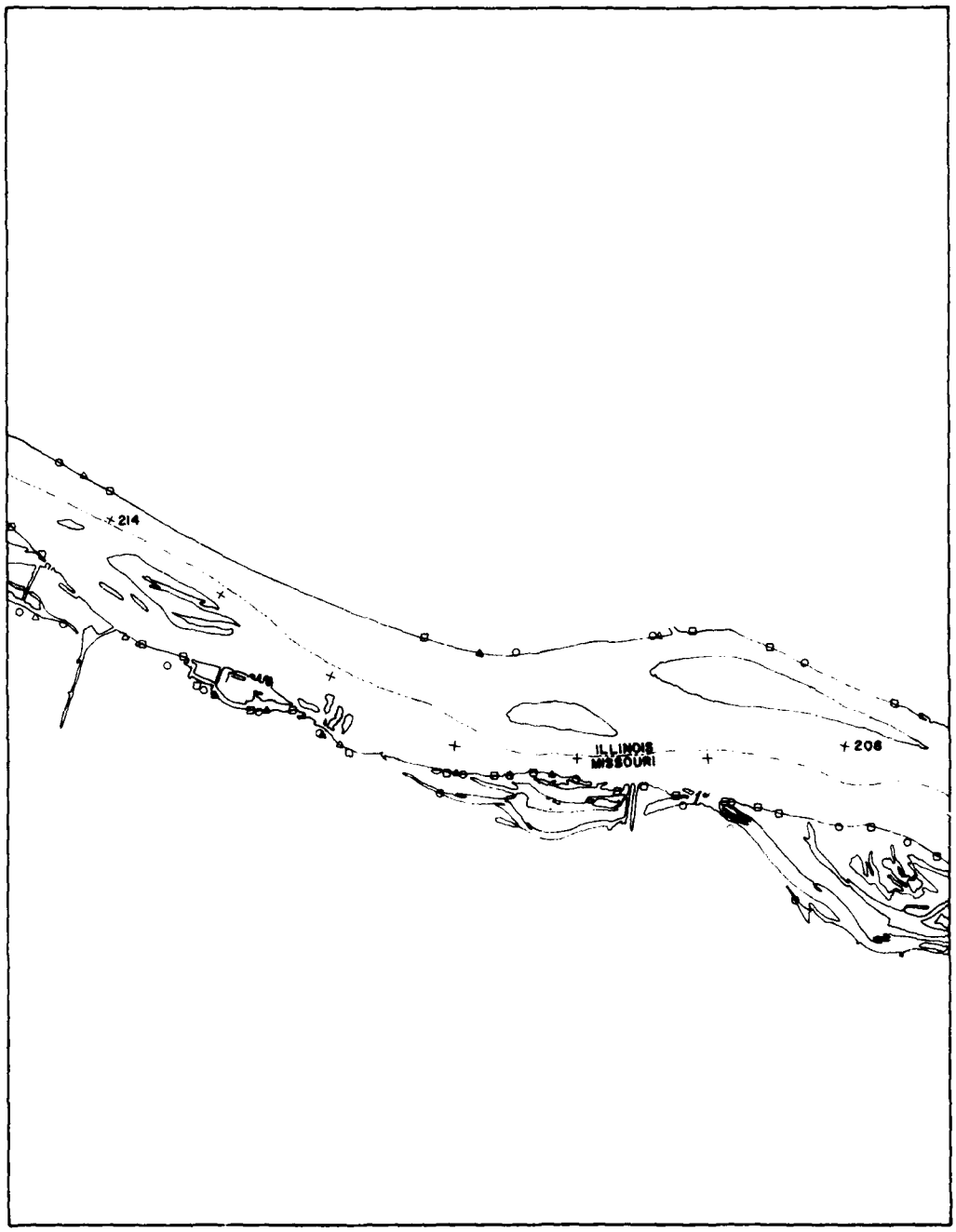


HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1953-56
○ – 1967-68
□ – 1975-76

ALTON QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 1000' 2000' 3000' 4000' 5000' 6000' 7000'

MAP 30

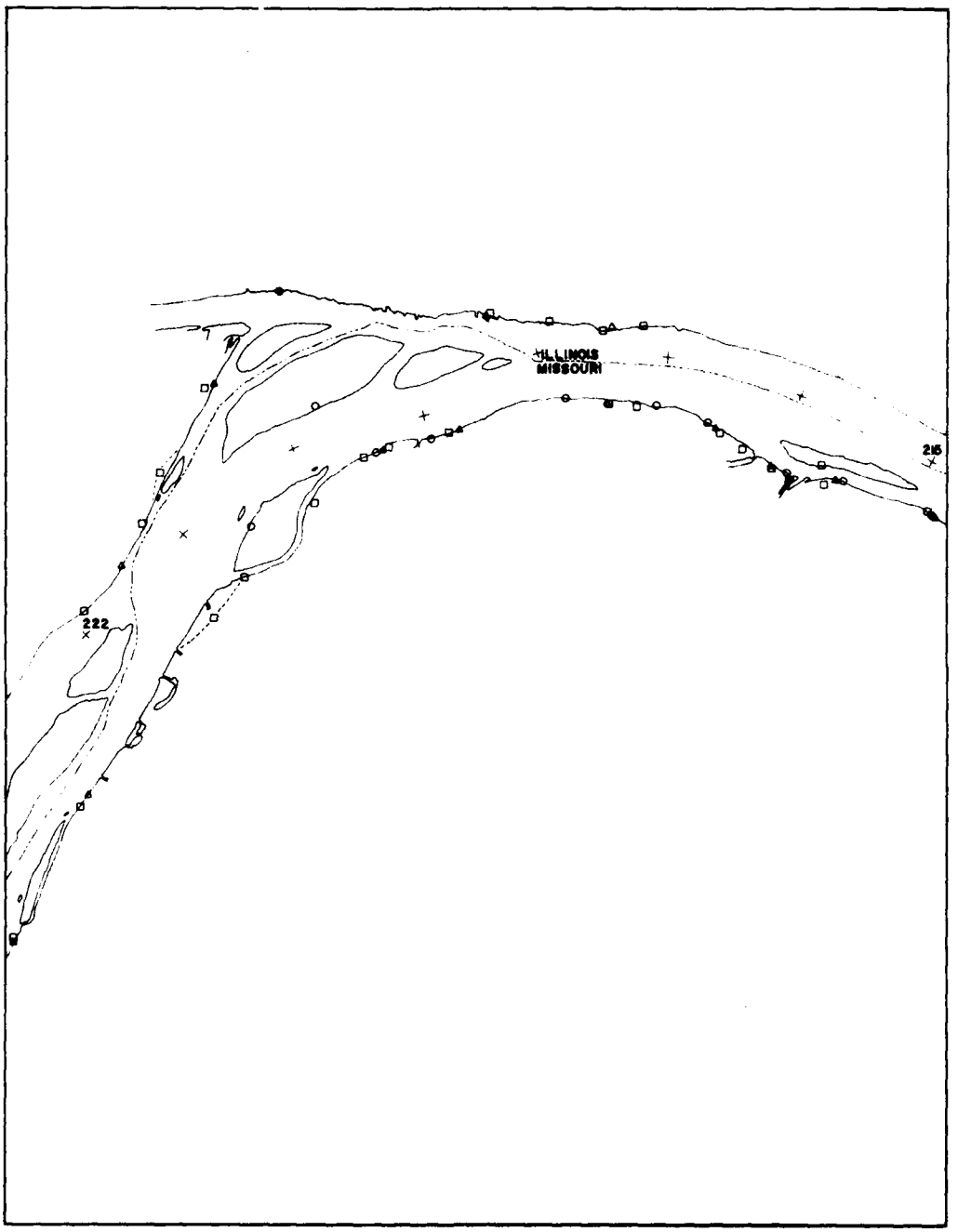


HIGH BANK LOCATION
× RIVER MILE
RESECTION POINTS
△ 1953-56
○ 1967-68
□ 1975-76

ELSAH QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 7000'

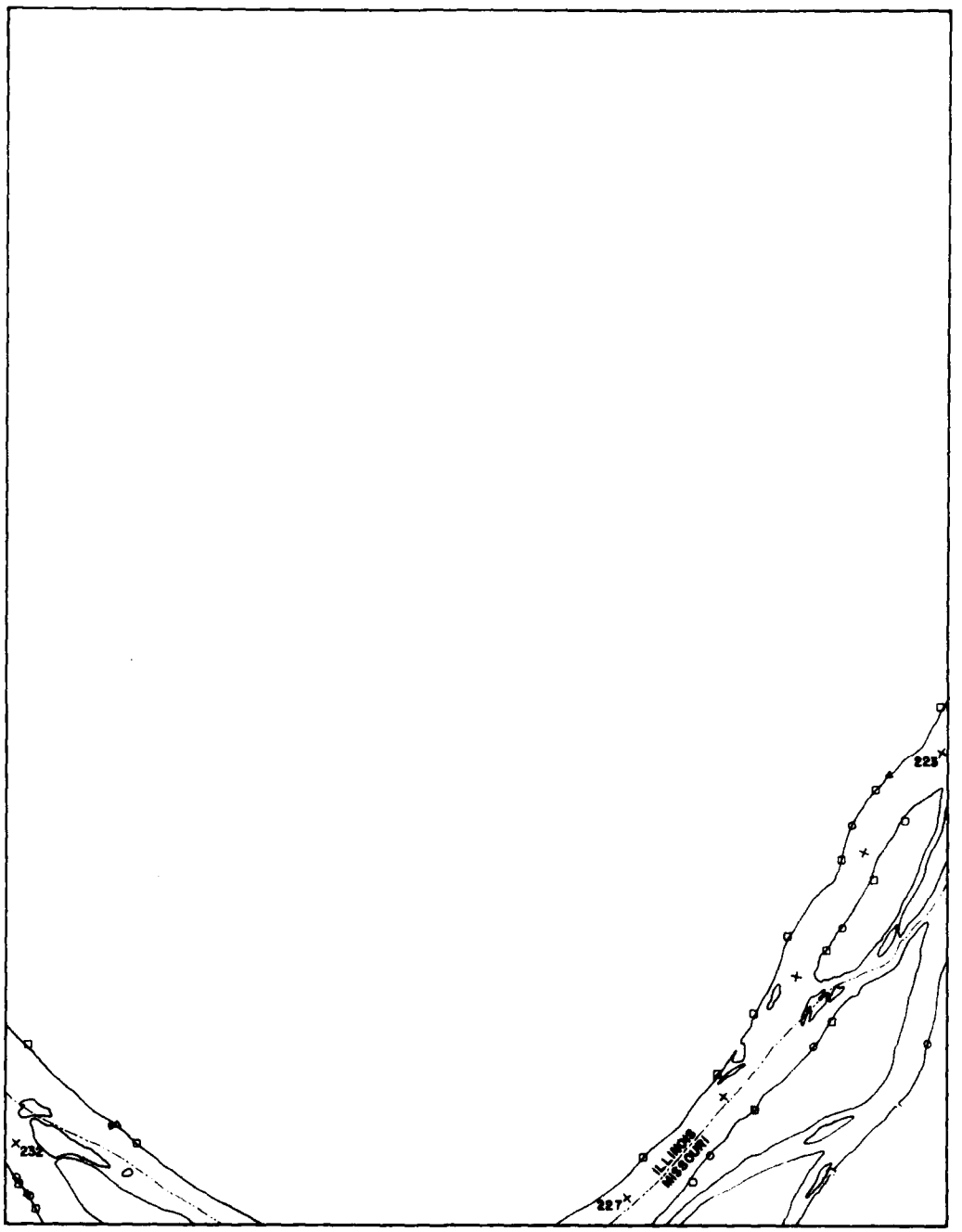
MAP 31



HIGH BANK LOCATION
RIVER MILE
RESECTION POINTS
△ - 1963-68
○ - 1967-68
□ - 1975-76

GRAFTON QUADRANGLE
7½ MINUTE SERIES
1974
1000' 0' 7000'

MAP 32

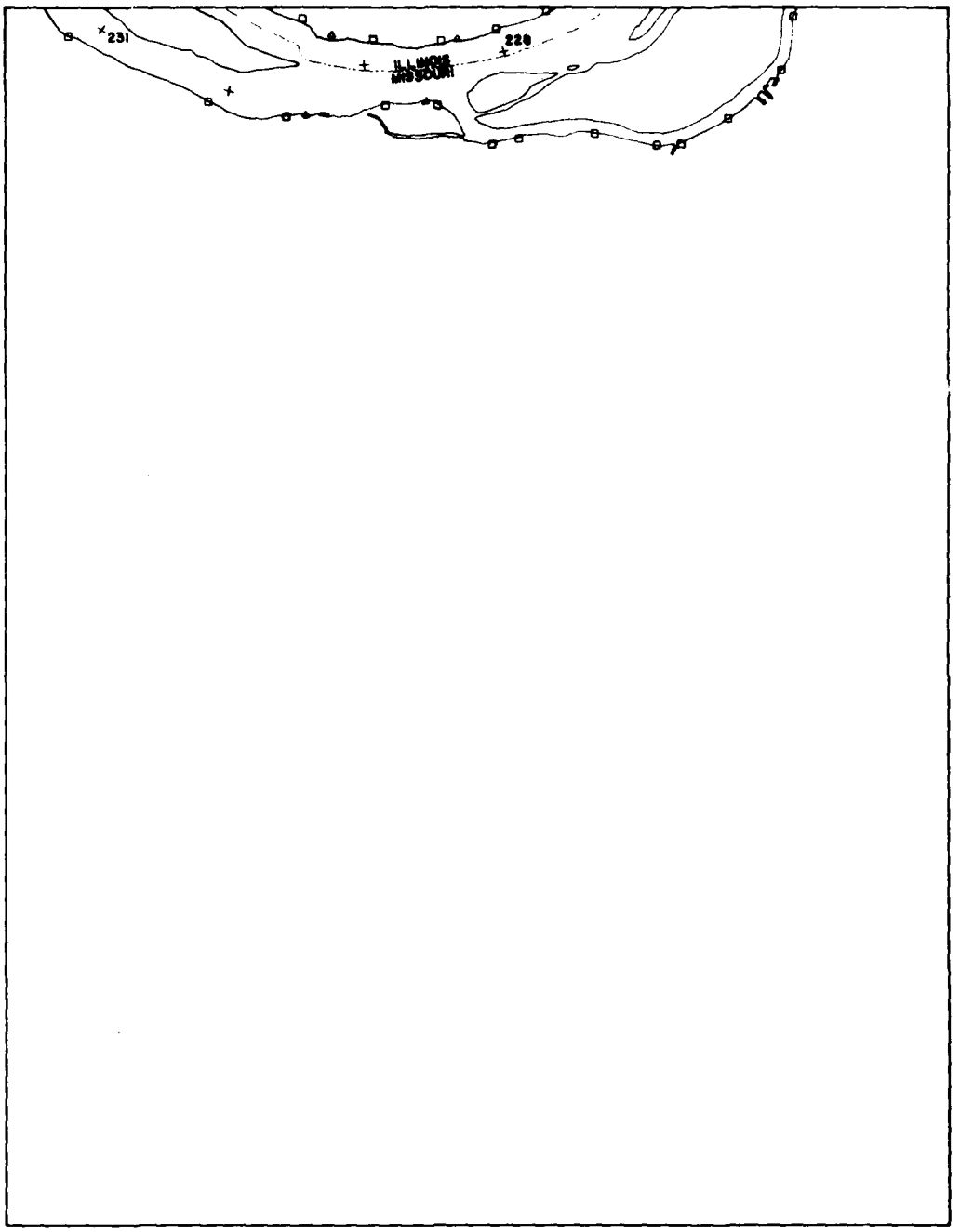


HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1963-68
○ – 1967-68
□ – 1975-76

BRUSSELS QUADRANGLE
7.5 MINUTE SERIES
1968

1000' 0' 7000'

MAP 33

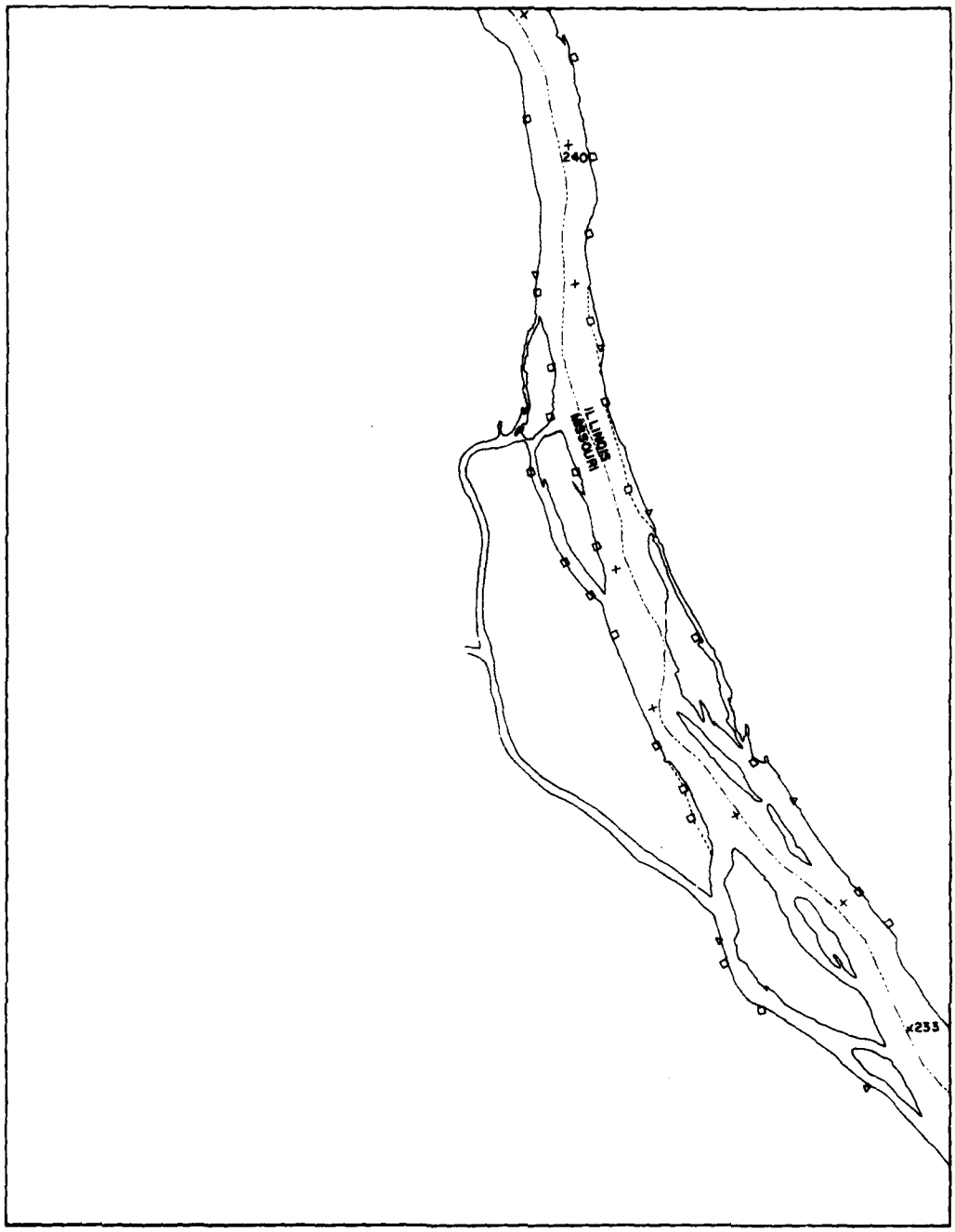


---- HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1953-56
○ – 1967-68
□ – 1978-79

KAMPVILLE QUADRANGLE
7.5 MINUTE SERIES
1974

1000' 0' 1000'

MAP 34



---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

WINFIELD QUADRANGLE
7.5 MINUTE SERIES
1968

1000' 0' 7000'

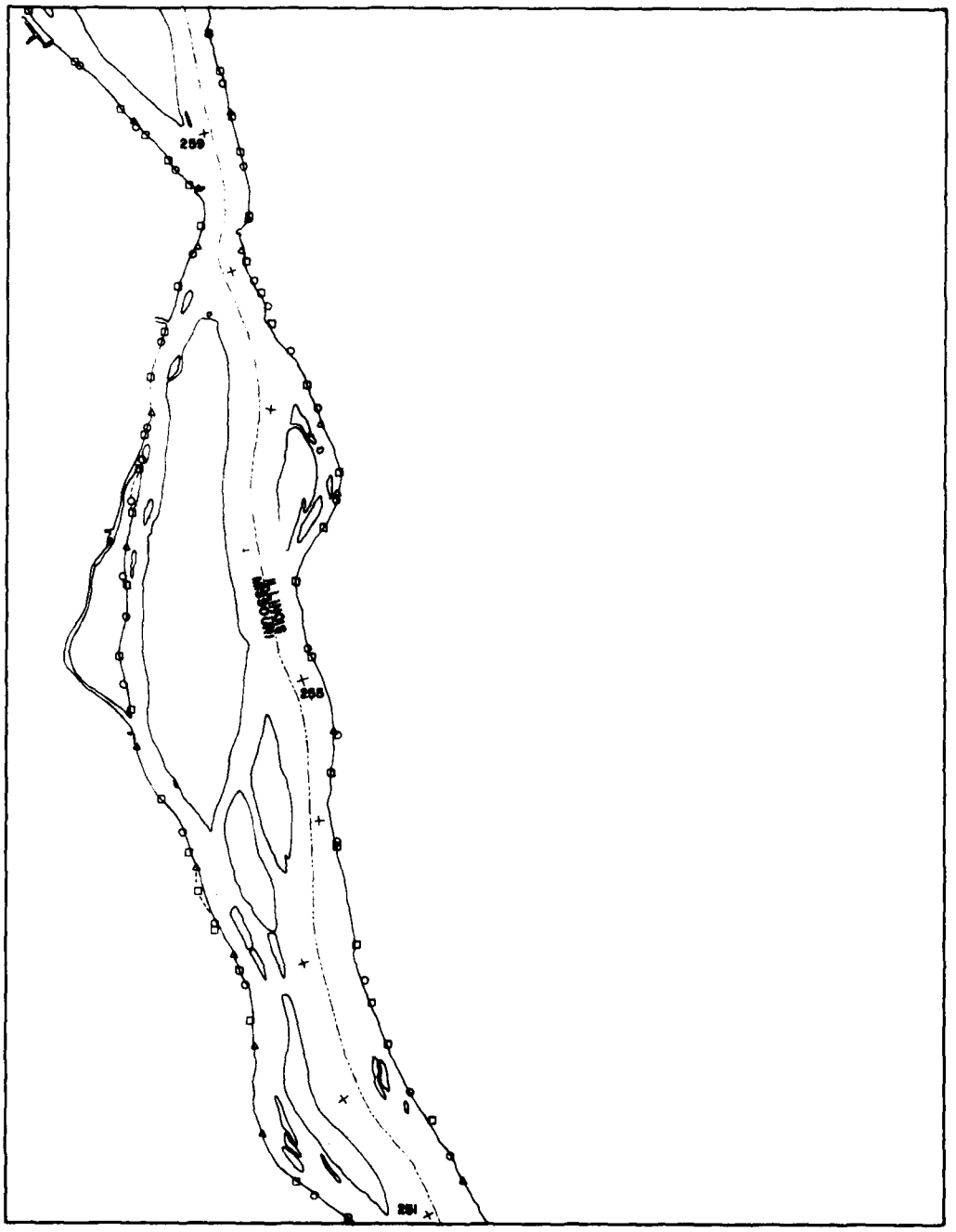
MAP 35

····· HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1953-56
○ – 1967-68
□ – 1975-76

FOLEY QUADRANGLE
7.5 MINUTE SERIES
1975

1000' 0' 7000'

MAP 36

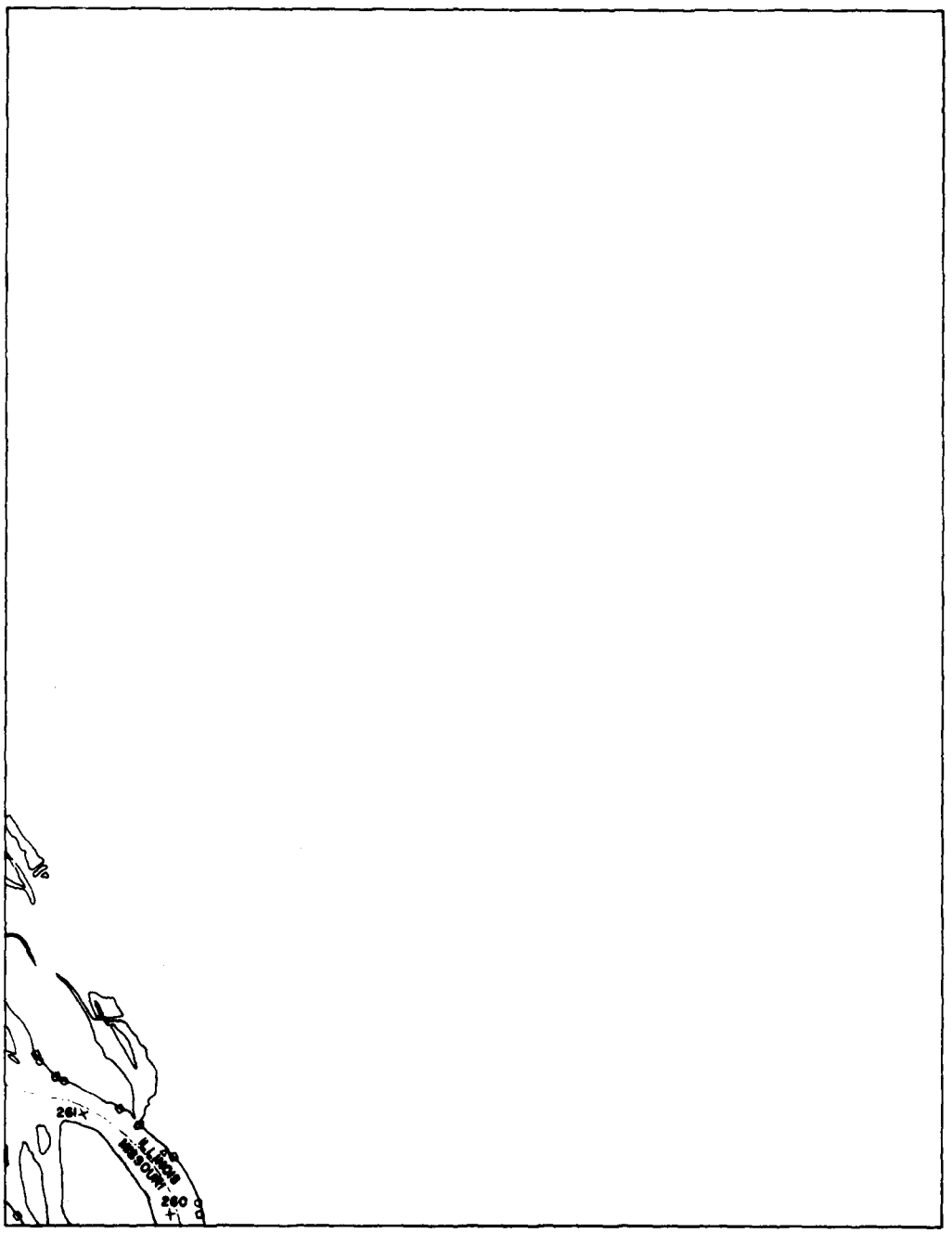


---- HIGH BANK LOCATION
x – RIVER MILE
RESECTION POINTS
△ – 1965-66
○ – 1967-68
□ – 1978-79

HAMBURG QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 37

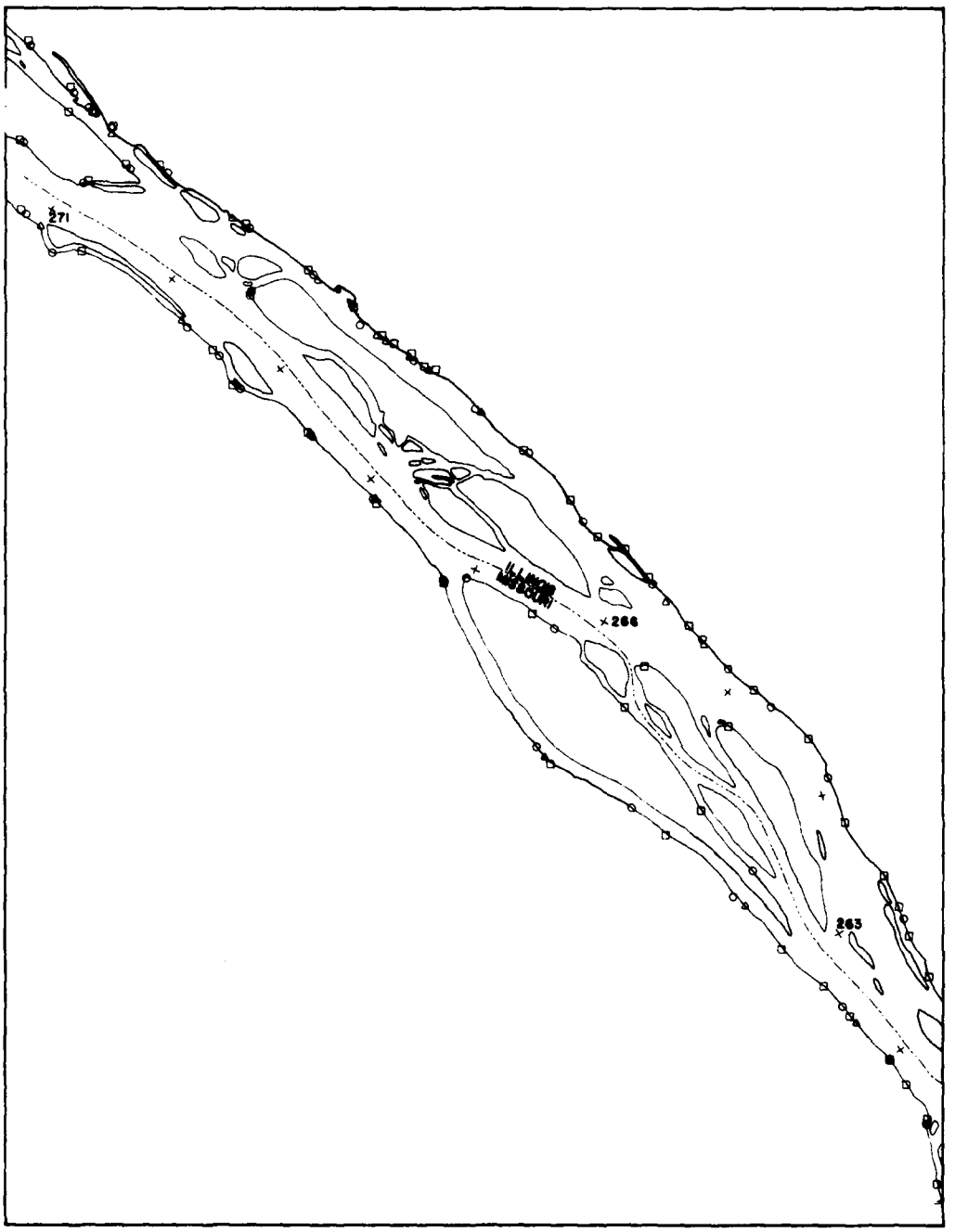


--- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-56
○ - 1967-68
□ - 1975-78

PLEASANT DALE VALLEY QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 38

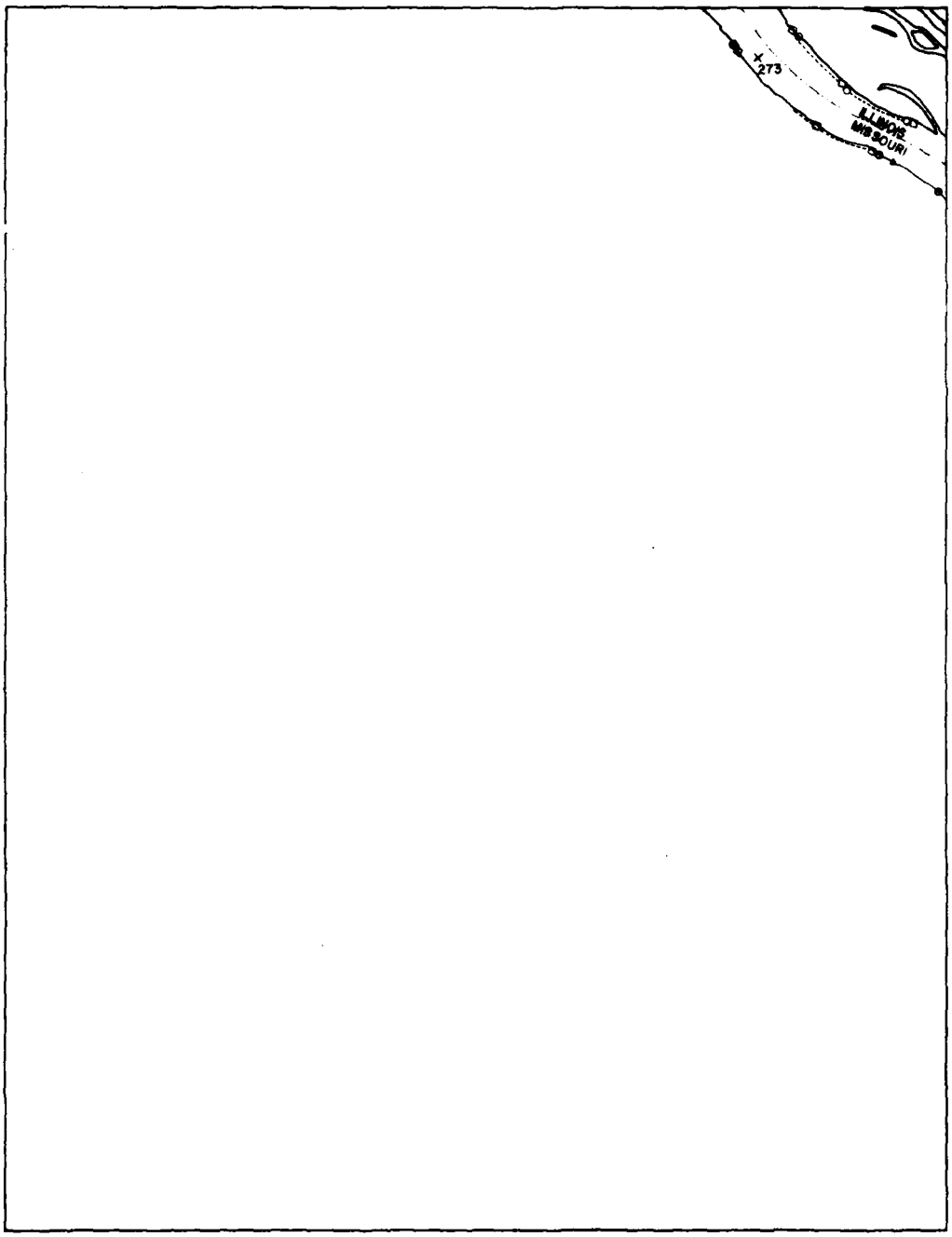


---- HIGH BANK LOCATION
× - RIVER MILE
RESECTION POINTS
△ - 1953-56
○ - 1967-68
□ - 1975-76

ANNADA QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 39

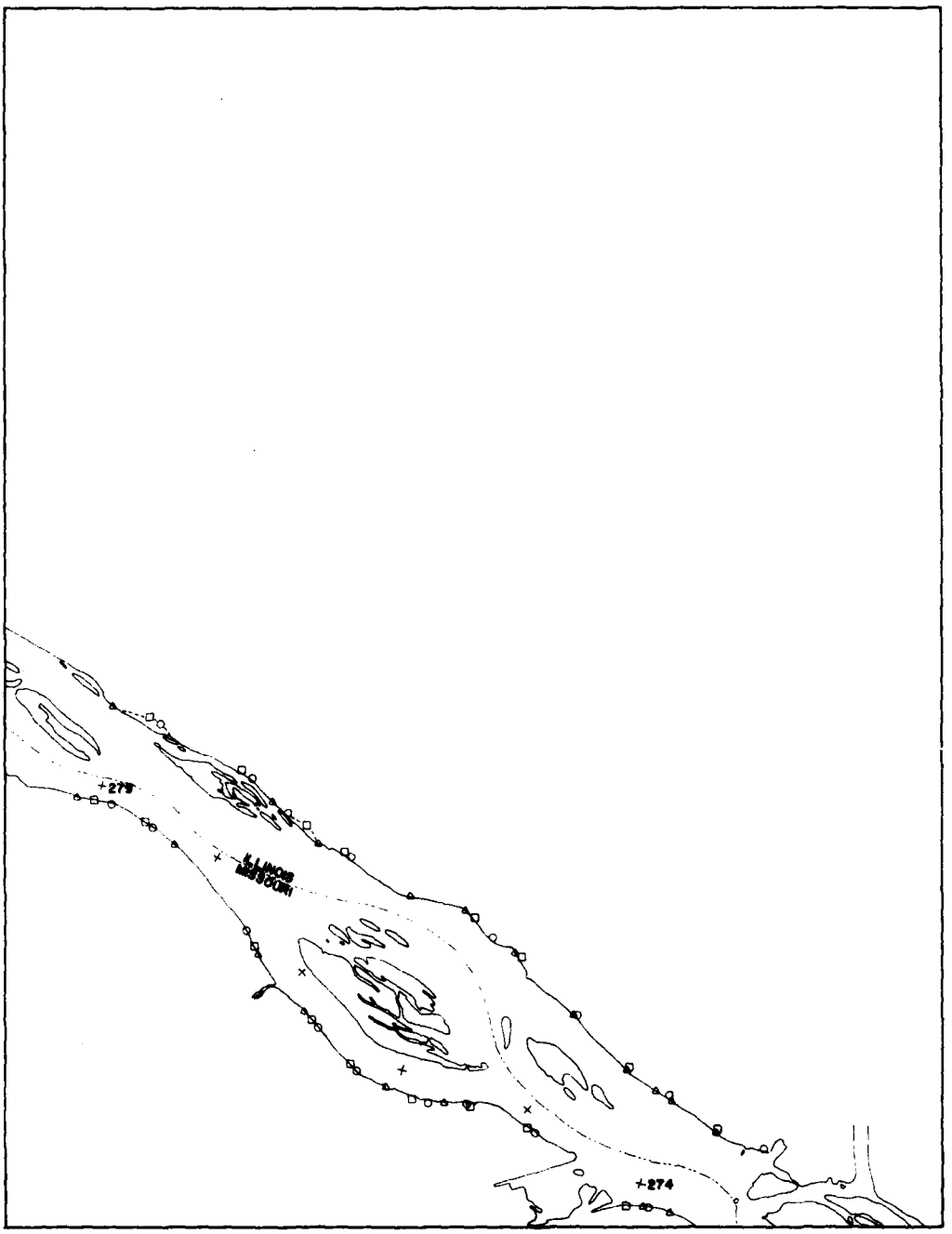


---- HIGH BANK LOCATION
x – RIVER MILE
RESECTION POINTS
Δ – 1953-56
o – 1967-68
□ – 1975-78

CLARKSVILLE QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 40

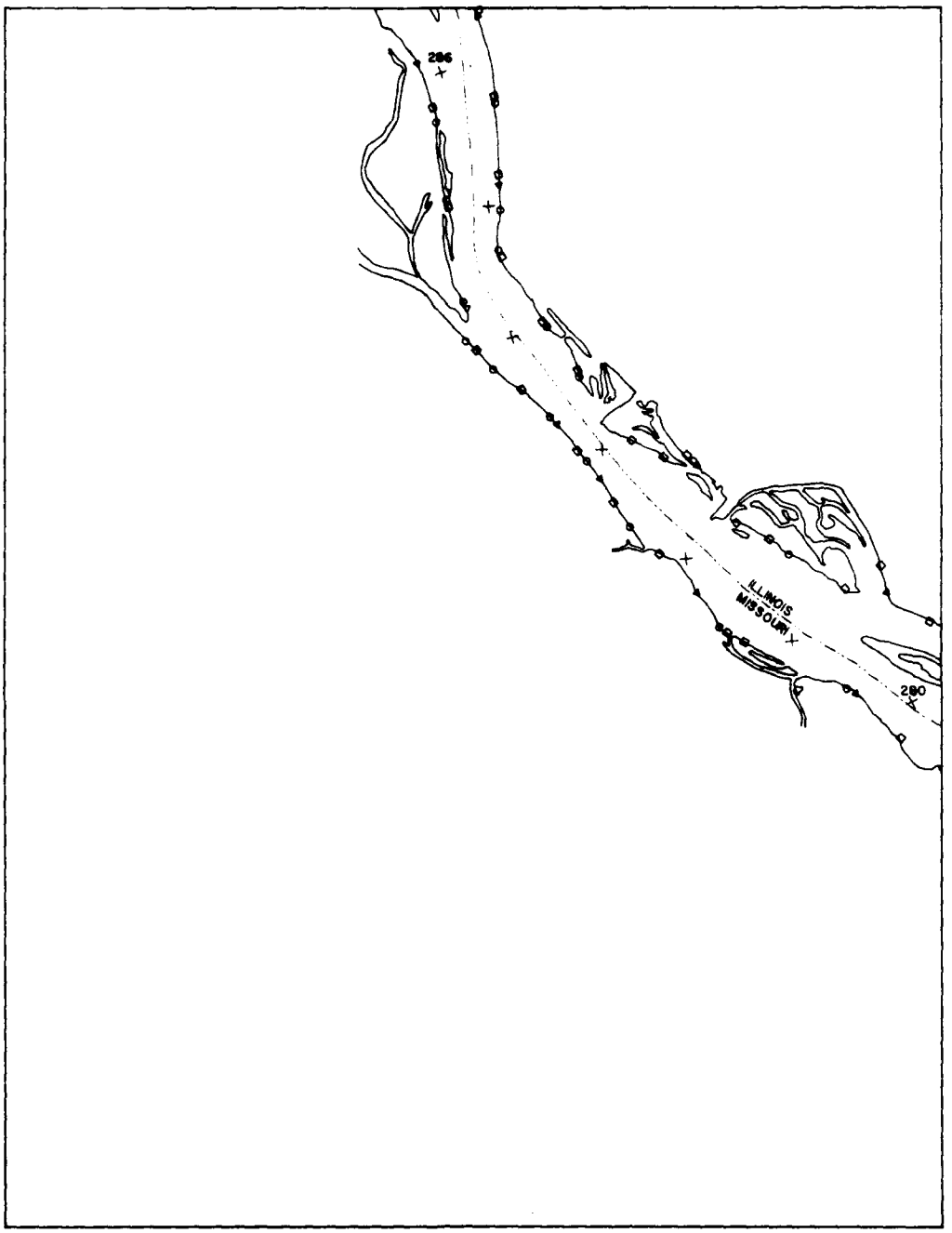


---- HIGH BANK LOCATION
× – RIVER MILE
RESECTION POINTS
△ – 1953-56
○ – 1967-68
□ – 1975-78

PLEASANT HILL WEST QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

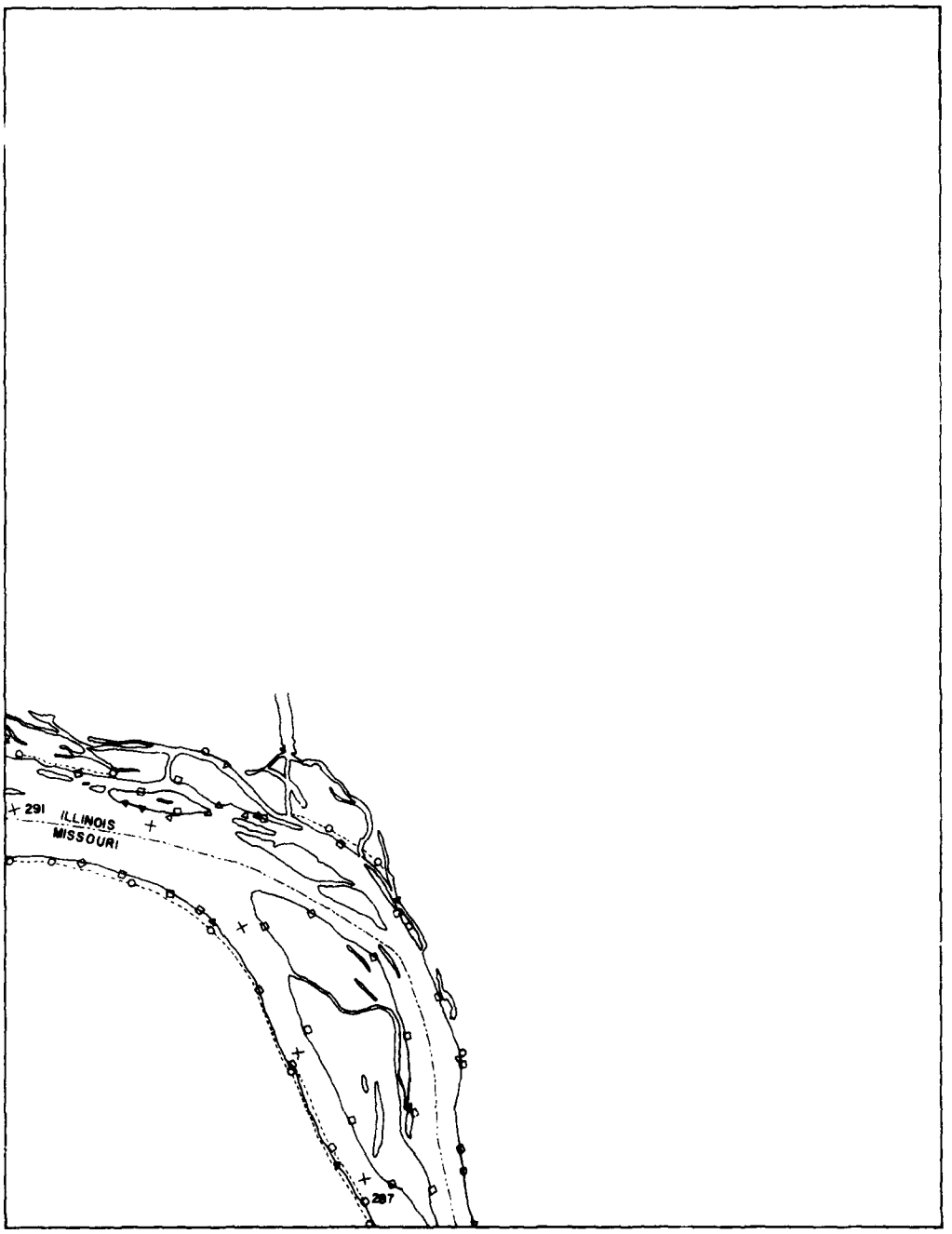
MAP 41



---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

LOUISIANA QUADRANGLE
7.5 MINUTE SERIES
1978
1000' 0' 7000'

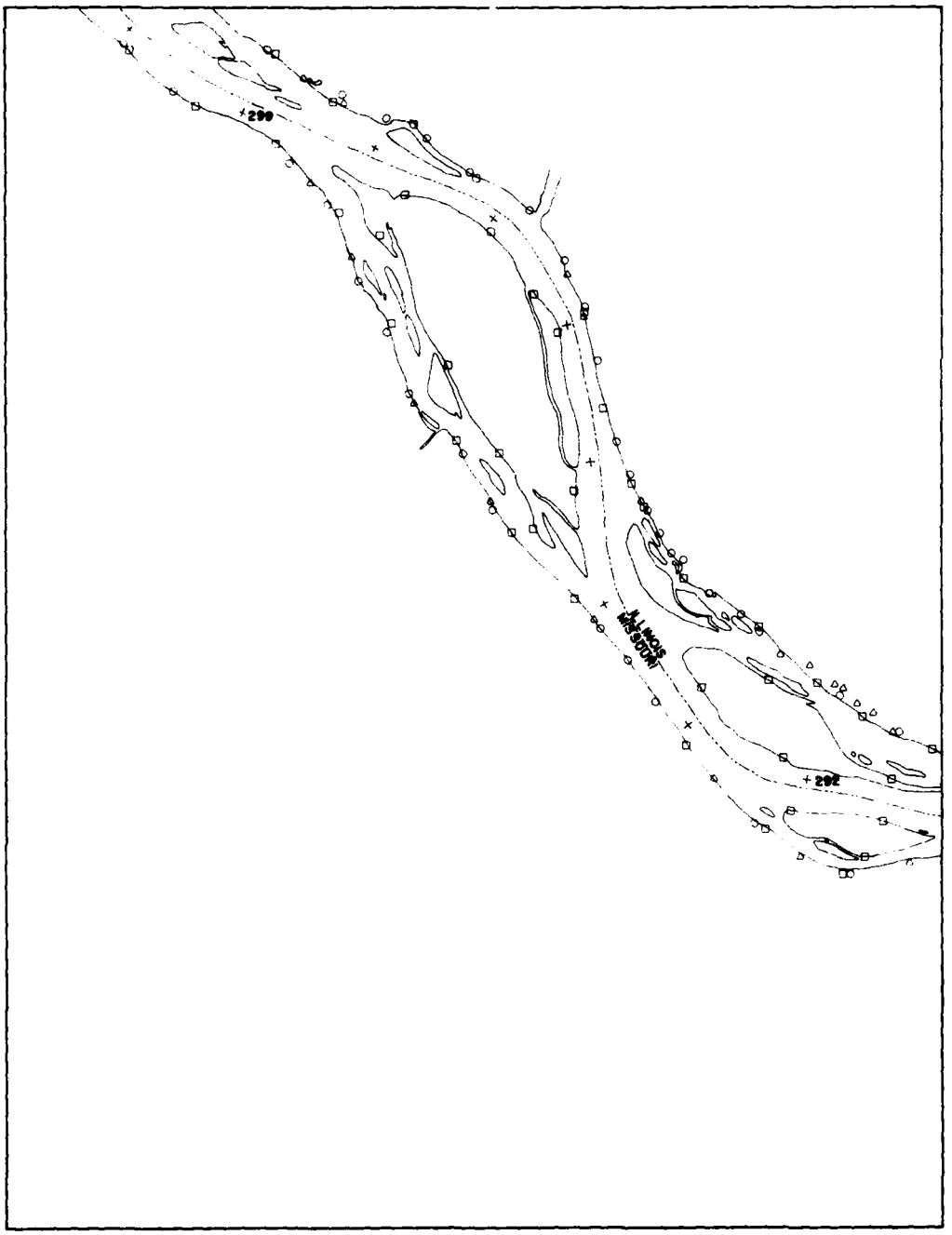
MAP 42



---- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ - 1953-58
○ - 1967-68
□ - 1975-78

ROCKPORT QUADRANGLE
7.5 MINUTE SERIES
1978
1000' 0' 1000'

MAP 43

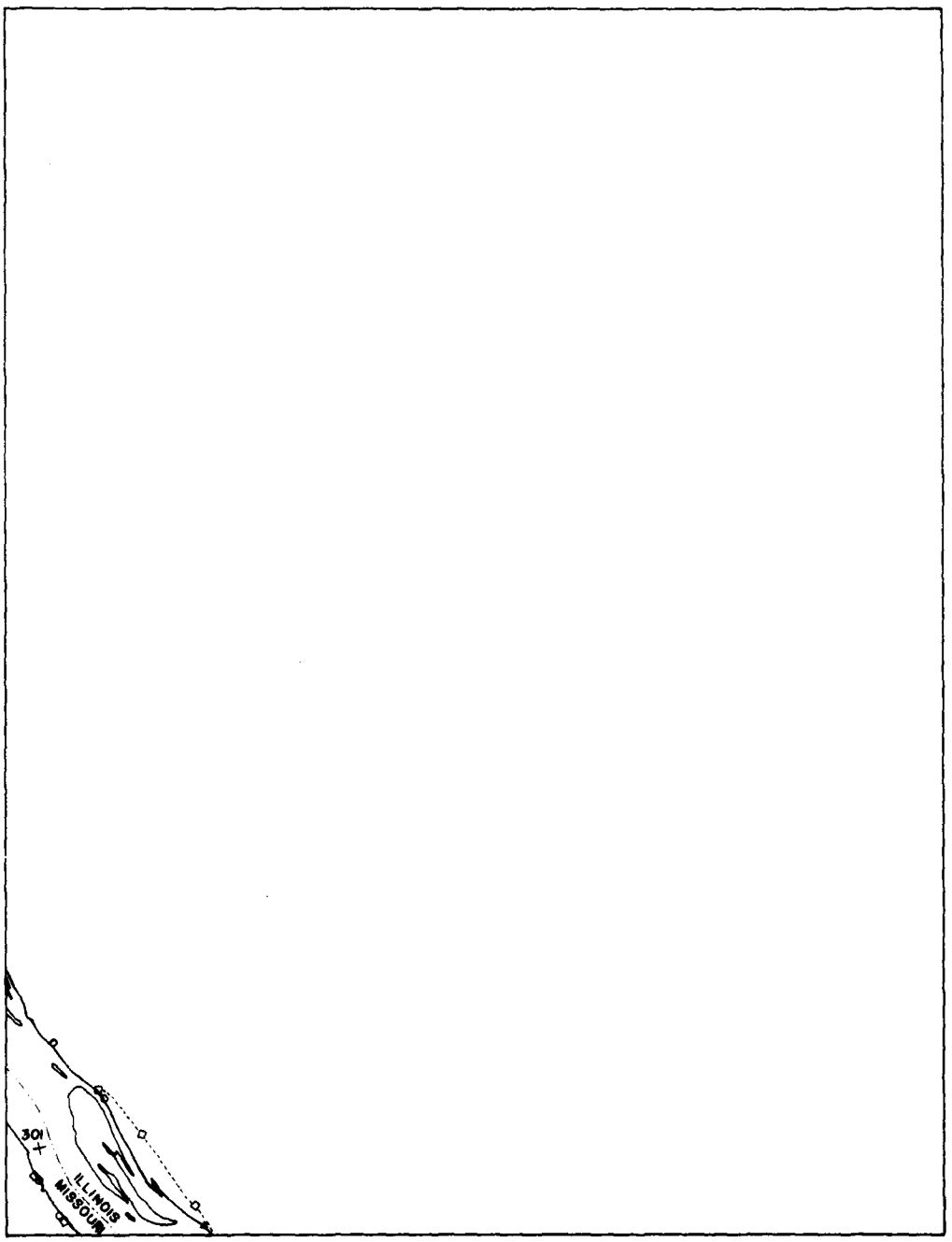


--- HIGH BANK LOCATION
x - RIVER MILE
RESECTION POINTS
△ 1953-56
○ - 1967-68
□ - 1975-76

ASHBURN QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 44



---- HIGH BANK LOCATION
X - RIVER MILE
RESECTION POINTS
△ - 1963-66
○ - 1967-69
□ - 1975-76

HULL QUADRANGLE
7.5 MINUTE SERIES
1978

1000' 0' 7000'

MAP 45